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The List of Journals dealt with will be found at the commencement of the volume. The following are recent additions :—

Courier of Wireless Telegraphy (Russian).

Journal of Industrial and Engineering Chemistry.

"T.S.F." (Revue Mensuelle de Radiotelegraphie).

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* Section "A" (Physics) contains abstracts from Papers on General Physics, Meteorology, Astronomy, Light, Heat, Sound, Electricity, Magnetism, Chemical Physics, &c.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

MARCH 1915.

GENERAL PHYSICS.

233. *Instrument for measuring Flame Velocities in Gas and Dust Explosions.* **J. D. Morgan.** (Engineering, 99. pp. 39–40, Jan. 8, 1915.)—A rotating drum carries a smoked paper and receives on it (1) a tuning-fork trace to indicate the time, (2) a dot produced by a wire in series with a sparking plug to initiate the explosion, and (3) a second dot produced by another wire in series with a large spark-gap which is made conducting when the flame of the explosion reaches it. The space between the sparking plug and the large spark-gap is occupied by the explosive gas to be examined, which is contained in a steel tube. To ascertain how the velocity varies along the tube there may be intermediate spark-gaps and connections to the smoked strip on the drum. E. H. B.

234. *Determination of Small Gas Pressures by an Oscillating Quartz Thread. Vapour Pressure of Mercury and Iodine.* **F. Haber** and **F. Kerschbaum.** (Zeitschr. Elektrochem. 20. pp. 296–305, 1914.)—Adopting a method of I. Langmuir's, the authors suspend a thin quartz thread, 7 or 8 cm. long, 0·13, 0·2 or 0·37 mm. diam., from the top of the vessel in which the determination is to be made, leaving the lower end free, tap the vessel, and observe the oscillations by the aid of a telemicroscope until the amplitude has decreased to half its value. Thinner and thicker threads are unsuitable; the threads are supplied by Schott, of Jena. The theory is given; and an appendix to it, by A. Einstein, is added. The constants of the formula were determined by experiments, at ordinary temperature, made in air, oxygen, and hydrogen of known pressures (McLeod gauge). The vapour pressure of mercury was determined in air and hydrogen; it is 0·00126 mm. at 20°, in agreement with Knudsen. The vapour pressure of iodine is 0·172, 0·009, 0·0025, 0·00088, 0·000057 at +19°, −9·7, −20·7, −28·9 and −48·3° C. respectively; these figures are in agreement with calculation and with Naumann and others. H. B.

235. *Lag in Marine Barometers on Land and Sea.* C. Chree. (Meteorolog. Office, Geophys. Mem. No. 8. pp. 173–185, 1914.)—The marine barometer is a so-called "Kew pattern" barometer, in which a portion of the tube is specially constricted in order to introduce great resistance to rapid motion of the mercury and so enable accurate pressure readings to be made on board ship even when the sea is very rough, when an ordinary mercury barometer cannot be read with accuracy on account of "pumping" of the column of mercury. The "Kew pattern" barometer is one in which the capacity correction is allowed for by suitable graduation of the scale in "apparent" inches, not true inches.

In 1880, Stokes discussed the theory of the sluggishness of the marine barometer, and found that when pressure is changing uniformly the reading of the barometer should be the same as the true reading L minutes previously, where L is the "lagging time" of the instrument, and is equal to 0·91 × time taken by the mercury to fall the inch from $1\frac{1}{2}$ to $\frac{1}{2}$ in. above the true level of the barometer at the time. This result does not depend upon the rate at which pressure is changing.

From experiments made at Kew Observatory with two marine barometers, it is shown that, in fact, the effect of lag is much greater than according to Stokes' formula, and that it depends partly upon the rate at which the pressure is changing. Thus the ratio of the observed to the calculated lagging time varies from 10 or 12 when the rate of pressure-change per hour is 0·0058 in. to 5 or 6 when the rate is 0·0242 in. per hour. On the other hand, readings made at sea on board the ss. *Hesperian* with the same two barometers appear to indicate that on board ship the effect of lag is exceedingly small, even smaller than it should be according to Stokes' formula. R. C.

236. *The Testing of Hydrometers.* (Bureau of Standards, Circ. No. 16, [16 pp.], Washington, 1914.)—The object of this circular is to present to manufacturers and others the information necessary to make possible the construction and verification of hydrometers on a uniform basis; to indicate the facilities now available at the Bureau of Standards for their verification, and to anticipate the adoption by the Bureau of more comprehensive specification for hydrometers. In considering hydrometer scales the testing of which shall be undertaken, the Bureau has largely been guided by present practice. In cases where the standard scales chosen differ from those frequently used, with respect to the standard temperature selected, temperature correction-tables, and, where possible, conversion-tables, to permit intercomparisons between the standard scales and other scales, have been prepared. These tables are published in Circular No. 19. Two types of hydrometers are comprised in these specifications—namely, hydrometers proper, and hydrometers which are combined with thermometers, called thermo-hydrometers. The following classes of hydrometers are included: (*a*) Density hydrometers; (*b*) Specific gravity hydrometers; (*c*) Per cent. hydrometers, indicating, at a specified temperature, the percentage of a substance in a mixture or solution with water (saccharometers, alcholometers, etc.); (*d*) Arbitrary scale hydrometers, indicating concentration or strength of a specified liquid, referred to an arbitrarily defined scale, at a specified temperature (Beaumé hydrometers, etc.). J. B. C. K.

237. *Units of Weight and Measure.* (Bureau of Standards, Circ. No. 47, [68 pp.], Washington, 1914.)—This circular is to supersede the Bureau of Standards Miscellaneous Publication on "Tables of Equivalents of the U.S.

Customary and Metric Weights and Measures," and contains an extensive series of tables. The units are defined and their inter-relation shown in tables, and tables are also given of equivalents from 1 to 999 units. Some special tables are appended, such as: Millimetres and decimal and binary fractions of an inch; Hundredths of an inch to millimetres, and *vice versa*; Comparison of various pounds and tons in use in the United States; Comparison of prices (French, German, English, and United States).

L. H. W.

238. *Temperature Coefficients of Edinburgh Transit Circle.* **R. A. Sampson** and **E. A. Baker.** (Roy. Astron. Soc., M.N. 75. pp. 69–81, Dec., 1914.)—Observations have been made with the object of determining the behaviour of the Edinburgh transit circle at different temperatures. Curves are given showing the variations of azimuth, level and temperature, distinct evidence of a daily period being indicated. C. P. B.

239. *Work of the Bureau of Standards in* 1914. **S. W. Stratton.** (Report to U.S. Secretary of Commerce [99 pp.], Washington, 1914.)—Gives a brief summary of the work completed, now proceeding, or contemplated, in all the various departments of the Bureau. L. H. W.

240. *Bifilar Properties of Twisted Strips.* **J. C. Buckley.** (Phil. Mag. 28. pp. 778–787, Dec., 1914.)—When a strip carrying an inertia bar is twisted, its period of vibration depends on the load, and this has been explained as a bifilar action in the fibres of the strip [see Abs. 1202 (1913)]. The total restoring couple (C) which acts on an inertia bar suspended by a strip of length l, breadth $2b$, and thickness $2d$, is, per unit angular displacement, $C = 16\,bd^3n/3l + 2Tb^3/3l$, where T is the tension per cm. breadth of the strip and n is the torsional rigidity. In the right-hand member of this equation the second term represents the couple due to bifilar action, and differentiation of the equation gives $dC/dT = 2b^3/3l$, showing that the C—T graph of any strip is a straight line which, if produced back to cut the axis $T = 0$, gives the value of n, for then the bifilar term of the original equation disappears. Without using the graph, the value of n can be obtained in any particular case by inserting the value of T. Where n is large the bifilar term approximates to zero unless d be very small, showing that for all but very thin strips the restoring couple is due to torsion alone. Experiments were made with strips of paper, aluminium, mica, celluloid, xylonite, steel, and phosphor-bronze, and C—T curves were drawn in each case. The results obtained agreed well with the theory outlined above. J. W. T. W.

241. *Elasticity of Ice.* **K. R. Koch.** (Ann. d. Physik, 45. 2. pp. 237–258, Sept. 1, 1914.)—In order to investigate further the large differences previously found in the elastic moduli of different specimens of ice [Abs. 1575 (1913)] experiments were undertaken both on the bending of ice bars and on the period of their torsional oscillation. In the first set of (bending) experiments the difficulties encountered, viz. (*a*) elastic after-effect, and (*b*) permanent deformation even under the smallest forces, rendered it desirable to reduce the acting forces as much as possible. It was therefore necessary to attain the utmost accuracy in the measurement of the resulting strains, and the optical method previously devised was again employed with some refinements. The results obtained were, for bars of ice whose axes were parallel to the frozen surface, $E_{90} = 957{\cdot}6$ kg./mm.^{2} whether the bending were in the plane of the breadth or of the depth of

the bar. For bars in which the axis was perpendicular to the frozen surface, $E_0 = 1120{\cdot}3$ kg./mm.^{2}. An attempt was made to discover whether the differences between these values and those of the previous year [50 %] were due to a warming of the ice above the melting-point and subsequent cooling, and experiments were made on bars formed by melting to shape. The values obtained differed from those found above, but the differences were not nearly as great as those existing between the two sets of experiments. The only explanation offered is that, as in the case of other elastic materials such as iron, copper, etc., different specimens of identical chemical composition show differences in elastic properties, so the same may well be true of ice formed under different conditions, especially seeing that it is of crystalline structure. It is worthy of consideration that in the previous year's experiments no regular difference was found in the elastic moduli of bars in which the axes had different orientations with respect to the frozen surface. This would be explainable on the assumption that the elementary crystals of which the ice was composed had no regular orientation in the mass.

The torsional experiments were also made by an optical method fully described and illustrated in the paper. The torsional modulus of a rectangular bar was calculated according to the St. Venant formula $F = lN/T_m bd^3(1/3 - d\lambda/166)$, where l, b, d, are the dimensions of the bar, N is the turning moment, T_m the angle of torsion, while λ is a tabulated function of d and b. The results obtained were, for a bar with its axis parallel to the frozen surface, $F_{90} = 300{\cdot}15$ kg./mm.^{2}, and for a bar with its axis perpendicular to this plane, $F_0 = 278$ kg./mm.^{2}. J. W. T. W.

242. *Collapse of Tubes by External Pressure.* **R. V. Southwell.** (Phil. Mag. 29. pp. 67–77, Jan., 1915.)—Forms a critical summary of recent experimental and theoretical work on tube collapse with special reference to Cook's experiments [see Abs. 1651, 1652 and *Errata* (1914)]. A theoretical discussion of the problems involved leads to the following conclusions :—If p is the (specified) working pressure of a tube then the collapsing pressure P may safely be taken as double this, and when collapse rings are not used the formula $P = 2ty_c/d\,[1 + (d^2y_c/t^2E)]$ may be used for finding the proportions of the tube. When collapse rings are used the formula $P = 2ty_c/d$ may be employed, and the rings should be placed at equal intervals s, given by—

$$s = (1{\cdot}73\,Ed/y_c)\sqrt{t^3/d^3}.$$

Collapse rings should only be employed when the dimensions of a tube are such that $t/d < \sqrt{y_c/E}$. In these formulæ, t is the thickness and d the diam. of the tube, y_c is the stress at yield-point in compression, and E is Young's modulus. J. W. T. W.

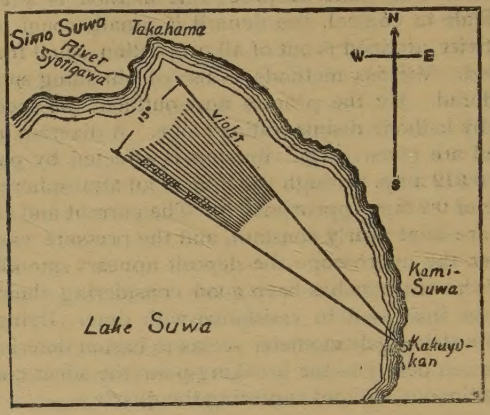
243. *Bending Stresses in Hooks and other Curved Pieces.* **A. Morley.** (Engineering, 98. pp. 321–322, Sept. 11, and pp. 377–378, Sept. 25, 1914.)—The author arrives at the following conclusions :—(1) There is no experimental evidence to show that calculations by the Andrews-Pearson formula give more reliable values than those obtained by the simpler Winkler formula. (2) That the use of either of these formulæ is, for most practical sections, attended by great risk of error, particularly that of Andrews and Pearson. (3) That nearly all published results on the subject are seriously in error. (4) That for practical purposes the results by either formula may be obtained from the simple formula for straight beams by empirical corrections, data for which are given in the original article. L. H. W.

244. *Silvering of Quartz Fibres by the Kathode Spray.* **H. B. Williams.** (Phys. Rev. 4. pp. 517–521, Dec., 1914.)—Quartz fibres coated with a layer of some electrical conductor are often used in the construction of delicate electrometers and similar instruments, and it is convenient to be able to prepare them with certainty and ease. The method usually employed to secure a conducting layer depends on the deposition of silver by one of the processes of chemical reduction. For some purposes this method is adequate, but the reduction is difficult to control, the deposit is usually rough and crystalline, and the conductivity attained is out of all proportion small for the weight of material deposited. Various methods in use of obtaining such a coating of metal are considered. By the process now outlined the necessary conductivity is secured by kathode disintegration alone. A diagram and also details of apparatus used are given. The silvering is effected by passing a direct current of about 0·012 amp. through the tube in an atmosphere of dry hydrogen at a pressure of 0·2 mm. approximately. The current and fall of potential across the tube are kept nearly constant, and the pressure varied as may be necessary. Under the microscope the deposit appears smooth and uniform. The durability of the coatings has been good considering their great tenuity. All the fibres have increased in resistance with time. Using the fibres at max. tension in the string galvanometer seems to hasten deterioration, and on increasing the tension nearly to the breaking-point the silver coating becomes electrically discontinuous without rupturing the quartz. A. E. G.

245. *Melting Metal Wires into Quartz-glass Vessels.* **R. Schaller.** (Zeitschr. Instrumentenk., Beib. No. 12. p. 130, June 15, 1914.)—It is often desired to attach ordinary glass, capable of being worked in the usual furnaces, to quartz glass which requires special treatment, particularly when only a small portion of a large and complicated vessel needs to be made of the latter variety. Owing to the exceptionally small coefficient of expansion and the high melting-point of quartz glass, the immediate attachment to it of ordinary glass and the direct melting-in of platinum wire are impossible. The junction can only be accomplished by a series of glasses, with a gradual transition of qualities. These require special working; the nearer the qualities of quartz glass being approached, the hotter has to be the temperature of the blast-flame, and either the oxy-hydrogen or the oxy-coal gas flame must be employed. Platinum, on account of its chemical properties, is convenient for leading-in wires, but, as its coefficient of expansion is relatively high, a large number of transition glasses are needed. In this respect tungsten and molybdenum are preferable; their cubical expansion coefficients are 130×10^{-7} and 150×10^{-7}, and they can therefore easily be melted into glass whose coefficient is between $100–170 \times 10^{-7}$. Iron-nickel alloys, which have a very low coefficient of expansion, do not give safe gas-tight joints, because the coefficient admittedly increases rapidly with rising temperature. J. S. D.

246. *The Horizontal Rainbow.* **S. Fujiwhara.** (Met. Soc., Tōkyō, J., March, 1914. Monthly Weather Rev. 42. pp. 426–430, July, 1914.)—The horizontal rainbow has been observed by several scientific workers in the past. The paper describes a bow seen in Japan, and puts forward a theory to explain the method of formation of these bows. An ordinary rainbow is seen as a series of cones radiating from the eye of the observer the common axis of which points directly away from the sun, while the semi-vertical angles differ for the different colours of the spectrum. The bow appears when these cones cut a suitable field of falling raindrops. Now if these rain-

drops are replaced by small water particles lying in a horizontal sheet over the surface of a lake, at the intersection of the coaxial cones with this sheet will be produced a "horizontal rainbow." Actually the whole bow will not be intense enough to be visible, but a portion of it will appear as a belt of colours, the width of which it is calculated may have any value between 2° and 16°. A bow of 15° is illustrated in the Fig. The theoretical form and



features of the bow are worked out and good agreement is found with the observed facts. The necessary conditions for the formation of these bows are thus a layer of fine water particles or mist over the surface of a sheet of water and bright sunshine. **K. Nakamura.** (Met. Soc. Tōkyō, J. 33. pp. 25–28, June, 1914. Monthly Weather Rev. 42. pp. 430–431, July, 1914.)—Nakamura describes several horizontal bows observed over a moat near the Central Meteorological Observatory at Tōkyō. A plan is given showing the bows as they were seen from several neighbouring positions.

J. S. Di.

247. *Photometry of Purple Twilight.* **P. Gruner.** (Archives des Sciences, 38. pp. 335–336, Nov., 1914.)—Observations were made of the relative intensity of the sky light near the horizon when the sun was some 5° or 6° below the horizon, and the band of light is of a purple tinge. The comparisons were made by means of a Nicol-prism photometer with an incandescent lamp at constant potential. The impression usually obtained of variation in the intensity is ascribed to the effect of contrast with the neighbouring regions of differently illuminated sky. C. P. B.

248. *Free Air Data in Southern California, July and August,* 1913. **W. R. Blair.** (Monthly Weather Rev. 42. pp. 410–426, July, 1914.)—The paper describes the results obtained from a series of free balloon ascents made at Avalon, and from captive balloon ascents made at the summit of Mount Whitney and at Lone Pine, a valley station 25 km. east of Mount Whitney. Twenty-three *ballon-sonde* ascents were made at Avalon, the instrument being carried by two balloons and having a float attached in case it should fall in the sea. Seven of the balloons reached 18 km. height and one of these rose to 32½ km., the greatest height so far reached in America. The ascentional rates were determined from the pressure-time records given by the meteorograph. The mean rate derived from the 7 highest ascents showed a con-

siderable increase with increase of height, from 3·1 m. per sec. near the surface to 4·2 at 11 km. The mean temperature curve from the same ascents does not show a minimum below 18 km. Temperature-altitude curves are given for each ascent. The lowest temperature observed was —67·5° C. at 16·5 km. on Aug. 3. A table is also given showing the absolute humidity results. In several cases the balloons were followed by a theodolite to the point of lowest temperature, and in all these cases an easterly component of the wind was found to set in at this point. On the summit of Mount Whitney a continuous record of the surface conditions was kept during the period Aug. 1–13. Comparing the temperatures with those found above Mount Weather, it is concluded that in summer, temperatures on mountains are higher than those at the same height in the free air. Three ascents with captive balloons were made from Mount Whitney and 4 from the Lone Pine valley station. The latter ascents, made shortly after sundown, all showed a marked inversion of temperature between the surface and 200 m. above it, amounting on the average to 6° C. Above 300 m. a regular temperature decrease set in. Some curious fluctuations of temperature found in the valley at Lone Pine are ascribed to the mixing of upper and lower currents of air which are at different temperatures. J. S. Di.

249. *The "Mistral."* **Gazaud.** (Comptes Rendus, 159. pp. 335–336, July 27, 1914.)—The mistral is a strong north-east wind which occurs in Provence, especially along the shores of the Mediterranean round about the mouth of the Rhône. The wind has frequently a low temperature, in spite of the rapid temperature-increase which it undergoes in consequence of the increasing pressure due to its descent from the high plateau of Central and Eastern France. The author finds that a high-pressure system over the south-west of France is always associated with mistral. The high-pressure system is frequently accompanied by a low-pressure system over the Gulf of Genoa, but mistral occurs occasionally in the absence of that low-pressure system. R. C.

250. *Haloes and their Relation to the Weather.* **A. H. Palmer.** (Monthly Weather Rev. 42. pp. 446–451, July, 1914.)—A record of the occurrence of both solar and lunar haloes has been kept at Blue Hill Observatory for some time past, and the records over the 20-year period 1891–1910 are here dealt with. It appears that solar haloes are most frequent in spring, with a mean number of 5·9 in March, and least common in the autumn, with only 2·3 in each of the months, Oct. and Nov. Lunar haloes are most frequent in winter and least in summer. The different lengths of the day and night in winter and summer must be taken into account in interpreting these figures. The figures show that the conditions must be very much less favourable for the formation of solar haloes in summer and autumn than in winter and spring. Considering the possible connection of rain with solar haloes it is found that there is a considerable tendency for the latter to be followed by precipitation within 36 hours of their occurrence. As haloes are most frequently seen in the cirro-stratus sheet which precedes an approaching depression, this is in accordance with what would be expected. As regards this association with cirro-stratus cloud, the author states that when no low clouds are present a halo is formed whenever a thin sheet of cirro-stratus exists in that part of the sky where the sun or moon is visible. The form of a typical cyclone is illustrated by several figures with special reference to these cirro-stratus, or halo-forming, cloud sheets. The paper concludes with a reference to the halo in Weather Lore. J. S. Di.

251. *The Haloes of November* 1 *and* 2, 1913. **L. Besson.** (Monthly Weather Rev. 42. pp. 431–436, July, 1914. From the French.)—Some very remarkable optical phenomena of the class of haloes were seen in the eastern half of the United States on Nov. 1 and 2, 1913. The author has collected many carefully prepared drawings and reports of these phenomena which are reproduced in the paper. At Springfield, Mo., where the haloes were exceptionally pronounced on Nov. 1, a cirro-stratus sheet of cloud quickly changed to alto-stratus, and this again to stratus. It is suggested that this probably indicates a rapid downward motion of the ice crystals of which the higher clouds were formed, which in turn points to these crystals being of unusually large size. The more complex forms of halo seen so well on this occasion may be due to this unusual size of the ice particles. The most common forms of halo are simply explained by the reflection and refraction of light from ice crystals. For the explanation of a second class of haloes, which are somewhat less common than the first class, as, for example, the tangent arcs to the halo of 22°, it is necessary to assume a system of elongated hexagonal prisms of ice which on account of their falling motion through the air are all arranged in the same horizontal position. Yet other phenomena can be explained by hexagonal prisms with their axes vertical. There are other types of halo, mostly of very rare occurrence, which cannot be explained by any form of ice crystals at present known. One of these is the 90° halo of Hevelius. An extremely rare phenomenon, which was seen on both Nov. 1 and 2, consisted of the oblique arcs of the anthelion. There are only 17 records of these arcs having been seen in the past. An interesting theory of their formation which was put forward by Bravais is examined and found to fail in several ways to explain satisfactorily the observed facts. [See also Abs. 155 (1915).] J. S. Di.

252. *A Wind Cave at Watarasé, Japan.* **S. Suzuki** and **T. Soné.** (Tôhoku Univ., Sci. Reports, 3. pp. 101–111, April, 1914.)—In many mountainous parts of Japan there are holes in the ground from which cold air flows out continuously during the summer months. In some places these are turned to practical account in the maintenance of low-temperature chambers for the storage of silkworms' eggs. Almost without exception these openings or "fûketsus" are found at the foot of a steep northern slope of a mountain. The present paper describes some experiments made on the fûketsu at Watarasé, at the foot of Mount Kanari, about 300 m. above sea-level. The mountain has the appearance of being an ancient volcano, and the whole mass seems to be very porous and spongy. It was found that while in summer cold air flowed out of the fûketsu, in the winter months the current was directed in the opposite way. This suggested that the cause of the phenomenon was convective flow through the whole porous mass of the mountain, directed downwards and out of the fûketsu when the outside air was warm relative to the interior of the mountain, and in the reverse direction in the winter when the opposite was the case. This theory was strengthened by the finding of an opening higher up in the side of the mountain into which air flowed in summer and from which a current flowed out in winter. Various measurements were made and a relationship was found between the rate of flow of air and the outside air temperature, so that the authors regard the theory put forward above as being satisfactorily established. J. S. Di.

253. *Formation of Glazed Frost.* **T. Okada.** (Met. Soc. of Japan, J. 33. pp. 15–24, May, 1914. Monthly Weather Rev. 42. pp. 284–286, May, 1914.)—

Glazed frost is a transparent smooth coating of ice covering trees or buildings or the ground, and caused by rain which freezes as it touches the objects. The condition for its formation is that a layer of air from which water is condensing and of which the temperature exceeds 0° C., should be superimposed above another layer in which temperature is below the freezing-point. Some authorities maintain that as the rain-drops fall through the cold layer they become supercooled to such a degree that on striking an object the rain is quickly converted into ice. Such an explanation would require the cold layer to be composed of comparatively calm air. The author mentions a case of glazed frost at Tōkyō in which the temperature of the surface of the ground on which the coating of ice was formed was +0·1° C., so that the abstraction of heat necessary to freeze the rain could not have been effected by the ground after the rain had fallen. A theoretical treatment of the rate of cooling of a rain-drop by evaporation as it falls through cold air is therefore elaborated and applied to the Tōkyō example. Taking the height from which the drops fell as 870 m., the original temperature of the rain as 2° C., the mean temperature of the air column as −1·5° C., the mean diam. of a raindrop as 2 mm., the rate of fall of a drop as 6 m. per sec., and the average relative humidity as 90 %, it appears that the drop attains the mean air temperature at 109 secs., and that on reaching the ground in 145 secs. its temperature is −2·3° C. R. C.

254. *Influence of Compressibility on Fluid Motion with a Spherical Obstacle and its Application to a Meteorological Problem.* **Y. Okada.** (Tôhoku Univ., Sci. Reports, 3. pp. 189–197, June, 1914.)—The object of the present paper is to study the effect of the compressibility of fluid, when the fluid is moving with a uniform velocity and a sphere at rest is placed in it. This subject has an application to meteorology. The motion of the atmosphere may be disturbed by the presence of a semi-spherical mountain. Under the assumption of the incompressibility of air, this problem was calculated by W. Schmidt and compared with observation.

The calculation of the present paper, allowing for compressibility, shows that if the velocity of flow is not large, the effect in question is very small. Only when the velocity of flow approaches to that of the propagation of the disturbance in the fluid does the effect of compressibility become perceptible. At different angles on the semi-spherical mountain these corrections are positive and negative, with points of no correction. E. H. B.

255. *Earthquake Registration.* **B. Galitzin.** (Acad. Sci. St. Pétersbourg, Bull. 9. pp. 619–631, May 15, 1914.)—An analysis is given in tabular form showing the numbers of earthquakes of various types recorded at 28 stations distributed widely over the earth's surface, with discussion of the possible influence of the type of instrument used on the detection of the vibrations. C. P. B.

256. *Avogadro's Constant and Atmospheric Transparency.* **F. E. Fowle.** (Astrophys. J. 40. pp. 435–442, Dec., 1914.)—In an earlier paper values were derived for the vertical transmissibility of radiation through dry air from observations made at Mount Wilson, which lies above the surface dust-layer. Certain correction factors were also deduced to allow for the presence of moisture. By means of Rayleigh's formula the number of molecules per cm.^{3} of dry air under standard conditions, n_0, was calculated from these transmission coefficients [see Abs. 1492 (1914)]. The present paper covers

the same ground as the earlier, but greater refinements are introduced into the work. The value thus obtained for n_0 is $(2{\cdot}70 \pm 0{\cdot}02) \times 10^{19}$ which is in excellent agreement with the best value from other methods $(2{\cdot}705 \pm 0{\cdot}005) \times 10^{19}$ (Millikan). The corresponding value of Avogadro's number, or the number of molecules per gm.-mol., is $(6{\cdot}05 \pm 0{\cdot}04) \times 10^{23}$. Incidentally it is remarked that a remnant of the volcanic dust introduced into the atmosphere by the eruption of Mount Katmai, Alaska, in 1912, scattering somewhat less than 3 % of the incident radiation, is indicated by the 1913 transmission coefficients. J. S. Di.

257. *Absorption of Light in Space.* **H. S. Jones.** (Roy. Astron. Soc., M.N. 75. pp. 4–16, Nov., 1914.)—The material collected in former papers relating to proper motion, spectral type, photographic and visual magnitudes [Abs. 376 (1913) ; 1400 (1914)] is discussed with the idea of obtaining evidence as to whether there exists any absorption of light in space. There appears to be a possibility of a small but appreciable loss of light due to selective scattering. In considering stars of the same spectral type and at the same distance, the more luminous ones appear to be bluer. C. P. B.

258. *Electrified Corpuscles Emanating from the Sun.* **H. Nagaoka.** (Math. Phys. Soc. Tōkyō, Proc. 7. pp. 397–403, Oct., 1914.)—The well-known effect of electronic emission from a hot lime kathode is considered in its possible application to the solar phenomena. The flocculi are composed to a considerable extent of calcium, and the author suggests that in view of the great affinity of this element for oxygen, any quantity of the two elements will most likely exist in the form of incandescent lime. The possibility of this emitting electrons in sufficient quantity to exhibit the phenomena of the solar chromosphere, and also partly to account for the disturbances in terrestrial magnetism, are also considered. C. P. B.

259. *Distribution of Elements in Solar Atmosphere.* **C. E. St. John.** (Astrophys. J. 40. pp. 356–376, Nov., 1914. Mt. Wilson Solar Observatory, Contrib. No. 88. Nature, 94. p. 401, Dec. 10, 1914. Abstract.)—From a detailed discussion of the results obtained by Mitchell at the eclipse of 1905, and of the author's own measurements of line displacements at Mount Wilson, it is concluded that there is abundant evidence for admitting the existence of a definite system of stratification in the solar atmosphere. The heights and flash intensities increase progressively with the solar intensity of the lines, and the radial displacements of lines vary progressively with the solar intensity, from large negative values for the strongest lines to larger positive values for the weakest lines. Several other collateral lines of evidence are found to give support to the conclusion, and it thus appears that we may consider that the vapours of the elements ascend in detectable amounts to different heights ; that the lines of any one element originat eat depths increasing with decrease of solar intensity ; that the enhanced lines are higher than unenhanced lines of equal solar intensity ; and that we see into the sun to greater depth at the red end of the spectrum than at the violet. The general summary is that the H_3 and K_3 lines of calcium are the lines of highest level, followed by the H_α line of hydrogen, and that, in the main, the heavy and rare elements occur in detectable amounts only in the lower portions of the solar atmosphere. C. P. B.

260. *Pyrheliometry.* **A. K. Angström.** (Astrophys. J. 40. pp. 274–281, Oct., 1914. Meteorolog. Zeitschr. 31. pp. 369–373, Aug., 1914.)—The

Ångström compensation pyrheliometer having been adopted as a standard by the International Solar Congress at Oxford, it is pointed out that a small source of error found in the construction needs to be considered. This arises from the fact that the temperature distribution in the two manganin thermo-strips is not identical. Theory and experiment show that the correction required is about + 1·3 per cent. C. P. B.

261. *Extinction of Ultra-violet Light in Earth's Atmosphere.* **E. Kron.** (Ann. d. Physik, 45. 3. pp. 377–398, Sept. 15, 1914.)—Discussion is given of numerous measurements of the limits of ultra-violet solar radiation recorded at various zenith distances, to determine the degree of extinction of the ultra-violet radiation by the terrestrial atmosphere; the limit of effective rays is near λ3250. C. P. B.

262. *Oxygen in the Sun.* **K. W. Meissner.** (Phys. Zeitschr. 15. pp. 668–670, July 1, 1914.)—The probability that oxygen may be present in the sun has been suggested by Runge and Paschen from evidence given by three red lines at λ7772, 7774, 7775 [see Abs. 827 (1914)]. The evidence is extended in the present paper by the results of accurate measurements on the solar doublet at λ8446. C. P. B.

263. *Areas of Calcium Flocculi on Spectroheliograms.* (Solar Physics Committee, Publ. [6 pp.], London, 1914.)—In past years the solar activity has been estimated according to the spotted area. Since the establishment of the spectroheliograph as a standard observatory instrument another important criterion has been provided in the areas of the bright flocculi which are seen on photographs taken with monochromatic calcium radiation. At the Indian station Kodaikanal, on the Palni Hills, the record for the year generally covers more than 320 days, and the measures from these plates thus form the chief basis for the investigation. The measurements were made by means of a *réseau* of squares of one-hundredth inch side ruled on glass, this being lightly clamped to the negatives, and the flocculi areas read off directly by a small magnifier. Tables are given showing the areas for 1906, 1907, 1908, with plotted curves showing the comparison of sun-spot and flocculi areas for each day of that period. C. P. B.

264. *Photographic Periodogram of Sun-spot Numbers.* **A. E. Douglass.** (Astrophys. J. 40. pp. 326–331, Oct., 1914.)—To enable the observer to obtain a quicker survey of the general system of periodicities in a series of observations, a photographic method of integration is described, the typical variation curves being cut out of white paper and pasted in order on a black surface. This composite diagram is mounted on an axis provided with clockwork and slowly rotated in front of a camera with a cylindrical lens over its objective, and a narrow horizontal slit in the focal plane; the sensitive plate is slowly moved downward across the slit during the exposures. [See Abs. 1796 (1913).] C. P. B.

265. *Variation of Wave-length of Fraunhofer Lines.* **E. Freundlich.** (Phys. Zeitschr. 15. pp. 369–371, April 15, 1914.)—Induced by the number of different views proposed to account for the small variations of wave-length of solar lines at the limit compared with the centre of the disc, the author examines them on the possibility of their being partly due to their passage through a varying gravitational field, on the principle of relativity developed

by Einstein and Nordström [see Abs. 1468 (1911)]. The results are compared with the values observed by Evershed at Kodaikanal for selected groups of lines. C. P. B.

266. *Heat Rays of Extreme Wave-length in Solar Spectrum.* **H. Rubens** and **K. Schwarzschild.** (Preuss. Akad. Wiss., Ber. 24. pp. 702–708, 1914.) —An investigation has been started for detecting radiations of extreme wave-length in the infra-red, beyond the region studied by Langley with the bolometer (up to 11 μ), by means of specially designed condensing mirrors and a sensitive microradiometer. C. P. B.

267. *Transit of Mercury, November* 6–7, 1914. **F. W. Dyson.** (Roy. Astron. Soc., M.N. 75. pp. 27–30, Nov., 1914.)—The different phases of the transit were observed under good conditions at the Royal Observatory, Greenwich. None of the observers saw the "black drop," or any halo round the planet, or any bright spot on the black disc. From the results corrections are given for the tabular place of Mercury, relative to the sun, which amount to about 2 seconds of arc. Seven good photographs were obtained with the photo-heliograph, reproductions of these being given with the paper. C. P. B.

268. *Diameter of Mercury.* **R. Jonckheere.** (Roy. Astron. Soc., M.N. 75. pp. 31–34, Nov., 1914.)—Observations of the diameter of Mercury were made during the transit of the planet across the sun's disc on 1914 Nov. 6–7. The records are given in detail, with some discussion as to possible departures of the shape from circularity. C. P. B.

269. *Water-vapour in Atmosphere of Mars.* **F. W. Very.** (Lowell Observatory, Bull. No. 65. Nature, 94. p. 518, Jan. 7, 1915. Abstract.)—A discussion is given of certain spectrograms of Mars and the moon taken by V. M. Slipher at the Lowell Observatory, Arizona, on Feb. 6, 1914. The bands at C, B and *a* were measured with a spectral-band comparator. It is concluded that the equatorial regions of the planet are excessively dry, and that the amount of oxygen in the Martian atmosphere is probably about half as great as in that of the earth. C. P. B.

270. *Atmosphere of Mars.* **W. H. Pickering.** (Monthly Weather Rev. 42. pp. 501–503, Aug., 1914.)—Abstracts are made from a series of popular articles, giving the main arguments for accepting the reality of the canals on the surface of the planet Mars. Attention is drawn to the presence of similar markings on the surface of the moon, when it is seen under a similar angle of view to that used for Mars with a telescopic power of about 500. Several well-known hypotheses concerning the possible nature of the Martian canals are noted, but the decision is left open as to whether there is any evidence for the existence of intelligent animal life on the planet. C. P. B.

271. *Stability of Direct and Retrograde Satellite Orbits.* **F. R. Moulton.** (Roy. Astron. Soc., M.N. 75. pp. 40–57, Dec., 1914.)—New analytical methods are introduced for determining whether a periodic orbit is stable or unstable. Application of these to a retrograde periodic orbit having the period of JVIII shows that this orbit is very stable, while a direct orbit of similar period was computed to be unstable. C. P. B.

272. *Photographic Measures of Saturn and its Rings.* **E. E. Barnard.** (Astrophys. J. 40. pp. 259–267, Oct., 1914.)—Photographs were obtained of the system of Saturn during Nov., 1911, with the 60-in. reflector at Mount Wilson,

using the long-focus combination and a Brashear enlarging lens. To secure sharper contrast a yellow colour-filter and a Cramer Instantaneous Iso plate were used. The exposures were about 10 secs. each. On the original negative the extreme diam. of the ring is 19·01 mm. The photographs were made within a few days of opposition, the phase effect being insensible. No eccentricity could be detected in the rings. Details of the measurements are given in several tables. The author agrees with a note by Hepburn, suggesting that the outer ring is transparent. C. P. B.

273. *Short Methods of determining Orbits from Three Observations.* **A. O. Leuschner.** (Lick Observatory, Publ. 7. pp. 3–20; 221–376, and pp. 459–503, 1913.)—The author sets forth in the first paper a method of deriving preliminary orbits of comets and planets without previous assumption regarding the eccentricity. In the second paper the applicability of the method is extended to longer arcs, and formulæ are derived for the correction of a preliminary orbit on the basis of arcs of any length. The third paper gives a solution of the more general problem of determining from geocentric observations the osculating elements of a satellite, planet, or comet, moving under the attraction of more than one mass. The original pages must be referred to for details. **R. T. Crawford.** (Ibid. pp. 377–454) gives a number of applications of Leuschner's methods. L. H. W.

274. *Calculation of Planetary Orbits.* **T. Vahlen.** (Preuss. Akad. Wiss., Ber. 29. pp. 782–790, 1914.)—A long analysis is given, showing the method of calculating the orbits of planets from the values given by three observations. C. P. B.

275. *Turner's Theory of Sun-spot Swarm of Meteors.* **R. A. Sampson.** (Roy. Astron. Soc., M.N. 75. pp. 82–92, Dec., 1914.)—Criticism is given of the new theory introduced by Turner to account for the production of sun-spots by a swarm of meteorites, circulating in an elongated orbit and replenished periodically by encounters of Saturn with the Leonid swarm [Abs. 828 (1914)]. The evidence available from old records is examined, and the conclusion is that there appear to be no observational data to support the view. C. P. B.

276. *Delavan's Comet.* **P. J. Melotte.** (Roy. Astron. Soc., M.N. 75. p. 27, Nov., 1914.)—Photographs of the comet discovered by Delavan were obtained with the 30-in. reflector and with a portrait lens of 3¼ in. aperture and 11 in. focal length, on Sept. 14, 20, 26, and 30, 1914. Two of these are reproduced to illustrate the development of the tail streamers. The comet had a bright nucleus of about the 6th magnitude. From this there extended a long straight tail for about 10 degrees. Another shorter and broader tail, curved in a marked degree, extends about 5 degrees from the nucleus. Near the head of the comet the axes of the two tails were inclined to each other about 12°. The broad tail was more sharply defined on the eastern side, and shows clearly the parabolic form of the envelopes. C. P. B.

277. *Proper Motions of Stars in Relation to Spectral Type.* **F. W. Dyson.** (Roy. Astron. Soc., M.N. 74. 9. pp. 733–744, Oct., 1914.)—An investigation is given of the proper motions of the stars in Carrington's circumpolar catalogue, determined by comparisons of the positions observed at Greenwich after an interval of 45 years. The stars all lie within 9° of the North Pole, and go

down to the limit of magnitude of the Bonn Durchmusterung. The results are given in the form of numerous tables. Several interesting conclusions are mentioned in the discussion ; it is found that a most striking feature is the small number of red stars with proper motions greater than 5·0″ a century. Next to these come the A stars, and then those from G_5 to K. The stars with largest proper motions are those whose type of spectrum is F to G. A long analysis is also given of the grouping of stars with relation to magnitude and distance. C. P. B.

278. *Stellar Magnitude Scales for Astrographic Catalogue.* **H. H. Turner.** (Roy. Astron. Soc., M.N. 75. pp. 57–66, Dec., 1914.)—This is the fourth note of a series dealing with a proposal for the comparison of the stellar magnitude scales of the different observatories taking part in the preparation of the Astrographic Catalogue [see Abs. 1511 (1912)]. The proposal is in effect that the number of images recorded under each unit of the magnitude scale be counted and tabulated. The method is shown to be valuable in the detection of systematic errors, and an example is given by the comparison of the Cape scale with that of Chapman and Melotte. It appears that the estimates for faint stars are affected by a considerable systematic error depending on the date of measurement of the plate, but the total numbers of stars on the plates are consistent. The ratio of faint to bright stars is much greater for one half of the zone than for the other, which may be due to different degrees of absorption of light in space. C. P. B.

279. *Distribution of Stars of various Spectral Types.* **K. Schwarzschild.** (Preuss. Akad. Wiss., Ber. 18. pp. 489–510, 1914.)—An analysis is made of the grouping of stars according to their light intensity, spectral type, and parallax, the summaries being given in tables showing the numbers of stars of various magnitudes for each type. C. P. B.

280. *Second Harvard Map of the Sky.* **E. C. Pickering.** (Harvard College Observatory, Circ. No. 185. Nature, 94. p. 518, Jan. 7, 1915. Abstract.)—In circular No. 71 there was described the production of the first Harvard map of the sky, consisting of 55 photographs taken with anastigmat lenses of 13-in. focal length mounted at Cambridge, Mass., U.S.A., and Arequipa in South America. Each plate was 8 × 10 in. and covered an area 30° square. Owing to this large field the definition at the corner of each plate was not so perfect as at the centre, so a new set of photographs has been made, the centres of which coincide with the corners of the first series. The set will be issued at the same price as the others, 15$ or £3. C. P. B.

281. *Spectra of Four Temporary Stars.* **W. S. Adams** and **F. G. Pease.** (Astrophys. J. 40. pp. 294–297, Oct., 1914. Mt. Wilson Solar Observatory, Contrib. No. 87. Nature, 94. p. 373, Dec. 3, 1914. Abstract.)—Hartmann in 1907 found that the spectrum of the Nova Persei of 1901 had become similar to the Wolf-Rayet spectrum. To find whether this disappearance of the nebular lines in the last stages of Novæ is general, the authors have photographed the spectra of four Novæ varying in magnitude from 10 to 14, the ages being from 2 to 23 years. The spectra were obtained from a small slit spectrograph at the focus of the 60-in. reflector, the exposure times varying from 2 to 16 hours. From the reproductions of these plates it is certain that the chief nebular lines are absent from the spectra of Nova Aurigæ and Nova Persei. The intensity of the continuous spectrum appears to increase with age of the

star. This identity of spectrum between aged Novæ and Wolf-Rayet stars, taken in connection with the well-known agreement of distribution relative to the Milky Way of Novæ and Wolf-Rayet stars, makes it probable that at least a portion of the latter are temporary stars in the later stages of their history. In the absence of knowledge as to the physical conditions under which the principal nebular lines are produced, it is no doubt best to ascribe their disappearance to a change in these conditions in the radiating material. In view, however, of the considerable amount of evidence of various kinds which tends to support the hypothesis that the phenomenon of a temporary star is due to the star entering a nebula, the suggestion that the disappearance of the chief nebula lines is coincident with the emergence of the star from the nebula may perhaps deserve some slight consideration. C. P. B.

282. *Spectral Criteria for Absolute Stellar Magnitudes.* **W. S. Adams** and **A. Kohlschütter.** (Astrophys. J. 40. pp. 385–398, Nov., 1914. Mt. Wilson Solar Observatory, Contrib. No. 89.)—Certain peculiarities have been noted during the investigation of numerous stellar spectra, of types ranging from A to M, such that two groups may be considered : (*a*) The continuous spectrum of the stars having small proper motions is relatively fainter in the violet as compared with the red than is the spectrum of the large-proper-motion stars. The magnitude of this effect appears to depend on the spectral type, and increases with advancing type between F_0 and K_0; (*b*) The hydrogen lines are abnormally strong in a considerable number of the small-proper-motion stars. Thus six stars showing well-developed titanium oxide bands characteristic of type M have hydrogen lines which would place them in types G_4 to G_6, and many others which show the bands strongly would be classified under type K from the appearance of their hydrogen lines. The hydrogen lines in the spectra of the large-proper-motion stars which show the titanium oxide bands are without exception very weak. These and other criteria have been utilised in the development of a system for the determination of absolute magnitudes, and examples are given of the results obtained for stars whose magnitudes are known from other sources, indicating that the new method gives results in close agreement. C. P. B.

283. *Orbits of Spectroscopic Double Stars.* **F. C. Jordan.** (Allegheny Observatory Publ. 3. Nos. 15, 16. Nature, 94. p. 491, Dec. 31, 1914. Abstract.) —Tables are given showing the reductions of spectrograms of the stars δ Orionis and RZ Cassiopeiæ, with the wave-lengths and chemical origins of the lines employed. C. P. B.

284. *Meaning of Third Star Stream.* **H. H. Turner.** (Roy. Astron. Soc., M.N. 75. pp. 2–4, Nov., 1914.)—The author suggests an answer to the query in Eddington's "Stellar Movements and the Structure of the Universe," as to the meaning of the third star-stream in drift O. If drift O is practically at rest in space, this may explain the phenomenon and be in agreement with the view that the two main star-streams are due to an oscillating motion of their constituent stars. The aggregate of stars at the time when they are reversing their direction of motion will give a general impression of their being stationary for a certain time. An important feature concerning this drift O is that all the stars of the Orion type appear to belong to it, and not to the two other drifts. It is suggested that they are there as the result of a kind of explosion at the centre of a nebulosity, and are now at or near their farthest limit. C. P. B.

285. *Determination of Orbit of Spectroscopic Binary.* **H. N. Russell.** (Astrophys. J. 40. pp. 282–293, Oct., 1914.)—A method is described for determining the orbit of a spectroscopic binary by a more direct process than that usually employed [see Abs. 1074 (1908)]. Examples are given illustrating the method and comparing the results with values given by older methods. C. P. B.

286. *Total Eclipse of Sun, August* 21, 1914. **J. Bosler** and **H. G. Block.** (Comptes Rendus, 159. pp. 766–769, Dec. 7, 1914.)—Preparations were made to secure photographic records of the spectrum of the corona, and of any variations in its distribution. The station selected was near Strömsund, in Sweden. The instruments comprised (*a*) large prism spectrograph with three dense flint prisms, and collimator and camera lenses of 72 cm. focal length; the spectrum obtained was 6·4 cm. long from λ656 to λ518. (*b*) A similar spectroscope with lenses of 53 cm. focus. (*c*) A photographic camera of 65 cm. focus, for direct pictures of the eclipse. All the instruments were attached to a clock-driven equatorial, the slits being adjusted parallel to the diurnal motion. Good weather prevailed at the time of eclipse, and satisfactory records were obtained. The corona was of the intermediate type, with the position of the solar axis clearly marked. The continuous spectrum of the corona extended without interruption from λ685 to λ395, and no trace was found of the chief corona line at λ5303. A new line was found in the red, however, at about λ6374·5 **H. Deslandres.** (Ibid. pp. 669–670, Nov. 16, 1914.)—Members of the staff of the Meudon Observatory journeyed to Strömsund to make observations during the total solar eclipse of Aug. 21, 1914. The chief instrument was an equatorial of 8 in. aperture, provided with two spectrographs and a photographic camera with colour-screens. The spectrographs give the spectrum of the corona in two stages, from λ7800 to λ5000, and from λ5000 to λ3600. On the first is found a new line, sharp and strong, superposed on the continuous spectrum of the corona. This line is not chromospheric, and has a wave-length near λ6375. The green coronal line at λ5303 was too faint to be recorded. **P. Carrasco.** (Ibid. pp. 740–741, Nov. 30, 1914.)—Observing at Theodosia, Crimea, with a powerful grating spectrograph, successful spectrograms were obtained extending from λ6900 to λ3750, showing the spectrum of the reversing layer and corona. Details of results will be given later, but mention is made of the feebleness of the green coronal ray, and the discovery of a new coronal line in the red, the wave-length being about λ6373·87. C. P. B.

287. *New Variables in Cluster* M_3. **H. Shapley.** (Astrophys. J. 40. pp. 443–447, Dec., 1914. Mt. Wilson Solar Observatory, Contrib. No. 91.)—Previous counts of variable stars in all but the central portion of the cluster M_3 have been published by Bailey (Harvard Annals 38; 78, part I.), showing the existence of 137 of these objects, the period being in all cases less than 18 hours. Recent photographs with the 80-ft. focus Cassegrain combination of the 60-in. reflector at Mt. Wilson have made it possible to extend the examination to the central portion of the cluster. More than 30 new variables have been noted, 23 of which are certain. A table is given of their positions, with magnitudes at maximum and minimum. C. P. B.

288. *Cause of Cepheid type of Variable Stars.* **H. Shapley.** (Astrophys. J. 40. pp. 448–465, Dec., 1914. Mt. Wilson Solar Observatory, Contrib. No. 92. Paper read before the Amer. Astron. Soc., Aug., 1914.)—Up to the present

time the oscillations of the spectrum lines in variables of the Cepheid type have been ascribed to elliptical motion in a binary system. The author examines the question whether it would be possible, on the evidence available, to discard this view in favour of there being intrinsic light-fluctuations of a single star. These stars present many anomalies compared with the ordinary spectroscopic binary, notable items being the curious relations between light-variation and radial motion. Attention is drawn to the essential identity of Cepheid and cluster variables, the irregularities in the light-curves, changes in colour and spectral type, all of which oppose the theory of a binary system being involved. Although no direct evidence is available, the idea of internal pulsations of a single star is favoured, this tending to produce periodic scattering or disruption of the photospheric layers by the rush of hotter gases from the interior. C. P. B.

289. *Relation between Wolf-Rayet Stars and Planetary Nebulæ.* **W. H. Wright.** (Atrophys. J. 40. pp. 466–472, Dec., 1914. Paper read before the Amer. Astron. Soc., Aug., 1914.)—Attention was drawn by Pickering in 1890 and 1891 to the points of resemblance between the spectra of Wolf-Rayet stars and planetary nebulæ, and about the same time Keeler announced his conviction that the nuclei of the planetary nebulæ were closely related to these peculiar stars. In 1894 Campbell published his exhaustive comparisons, both photographic and visual, of both classes of objects. Investigation of the spectrum of the Wolf-Rayet star B.D. + 30° . 3639 shows that certain nebular lines are undoubtedly present, but whether they belong to the star proper or the surrounding envelope is uncertain. Recent photographs of the planetary nebula N.G.C. 6572 show the spectrum of the nucleus isolated as a narrow band of continuous spectrum, and containing the characteristic line λ4686, although this does not exist in the outlying parts of the nebula. A longer exposure also shows a faint broad emission band at λ4057, and a faint broad nucleus band at λ5807. These three lines agree very closely with the most characteristic Wolf-Rayet bands, suggesting that the nucleus is of the Wolf-Rayet type. This made it a matter of interest to see if on more minute examination the so-called hydrogen envelope of B.D. + 30°. 3639 might be regarded as a true planetary nebula. With long exposures the plates show all of the brighter nebular lines. Thus in two cases we have planetary nebulæ possessing Wolf-Rayet nuclei. Extended observation of other objects readily provided further confirmation of this view. C. P. B.

290. *Distribution of Eclipsing Variables in Space.* **H. N. Russell** and **H. Shapley.** (Astrophys. J. 40. pp. 417–434, Dec., 1914.)—Having computed the elements of some 90 eclipsing variables, estimates are made of their distance by utilising their observed magnitudes and spectral types. The positions in space are tabulated according to their calculated distance in *light-years* from the galactic plane. C. P. B.

291. *Details of Stellar Spectra.* **F. E. Baxandall.** (Solar Physics Committee Publ. [38 pp.], London, 1914.)—Tables are given illustrating the discussion in detail of the spectra of β, γ, ϵ, κ, ζ, and ι Orionis, showing the relative intensities and probable chemical origins of the lines. A special discussion is devoted to the spectrum of α Orionis (Betelgeuse) and its relation to the spectrum of α Böotis (Arcturus) and the solar Fraunhofer spectrum. It is shown that the lines strengthened in intensity in passing from the solar spectrum to that of α Orionis are chiefly due to Ti and V. The lines involved

are mainly those of the *arc* type rather than the *spark* type. The spectrum of γ Cassiopeiæ shows certain peculiarities of dark and bright lines, and a table is given showing the wave-lengths, probable origin and character of the lines measured between λ3819, and λ4861·5. An instructive diagram shows the sequence of intensities of typical lines in the spectra discussed in the paper. C. P. B.

292. *Spectrum of* 10 *Lacertæ.* **E. B. Frost** and **F. Lowater.** (Astrophys. J. 40. pp. 268–273, Oct., 1914.)—Special attention has been given to the accurate determination of the wave-length of the spectrum lines of this star, chiefly on account of their importance in relation to laboratory identifications. The line near λ4686 is very sharply defined in this spectrum, and the adopted wave-length is 4685·90. Several lines of silicon also receive attention. C. P. B.

293. *Phenomena of New Stars : Solar Physics Observatory.* (Solar Physics Committee, Publ. [63 pp.], London, 1914.)—Most of the known facts concerning the spectra of new stars at various stages of their evolution are here collated, and discussed in relation to the general evolutionary classification of stellar spectra. Of special interest is the reproduction of a series of spectra of Nova Geminorum (1912), taken at Madrid by Iniguez. This shows what may be termed the life history of the Nova from 1912, March 16 to April 16, during which time the spectrum changes were very great. Numerous tables are given to show the comparison of Nova spectra with those of Wolf-Rayet stars, nebulæ, etc., and a chart shows the relation of the known Novæ to the Milky Way, the majority lying in or near it. C. P. B.

294. *Short-period Variable SZ Tauri.* **Leavitt.** (Harvard College Observatory, Circ. No. 186. Nature, 94. p. 518, Jan. 7, 1915. Abstract.)—From 210 plates taken between Oct.,1891, and Feb., 1914, a determination has been made of the orbit of this interesting variable. The period found is 3·1484 days. C. P. B.

295. *Spectroscopic Orbit of RX Herculis.* **H. Shapley.** (Astrophys. J. 40. pp. 399–416, Nov., 1914. Mt. Wilson Solar Observatory, Contrib. No. 90.)—It is shown that the solution for the elements of the spectroscopic orbit of a faint star is easily possible when only a few measures of the radial velocity have been obtained, provided that the system is also an eclipsing binary, and provided that the period, the epoch of minimum, the eccentricity, and the longitude of periastron have been determined from the light curve. A new photometric orbit of RX Herculis has been computed, and alternate minima are found to differ in depth by nearly a tenth of a magnitude. The stars are nearly equal in size, and are sensibly spherical. Their surfaces are separated by three times the radius of the larger star. Spectroscopic orbits of both components have been derived from measures of the lines on three plates made with the Bruce spectrograph at the Yerkes Observatory. C. P. B.

296. *Nebula Line* λ3729. **W. H. Wright.** (Royal Astron. Soc., M.N. 75. pp. 20–22, Nov., 1914.)—Attention is drawn to the possibility of misinterpretation of prismatic camera images of the Orion nebula, in that of the two nebular lines at λ3726·4 and λ3729·0 the former is much the brighter, and probably contributes the major portion of the image in a photograph of the spectrum [Abs. 47 (1915)]. This would affect Nicholson's statement as to the origins of the various nebular radiations. C. P. B.

LIGHT.

297. *New Crystal-grinding Goniometer.* **F. E. Wright.** (Washington Acad. Sci., J. 5. pp. 35–41, Jan. 19, 1915.)—Details are given of a new grinding goniometer with which crystal faces can be ground with a precision of 1′ or greater, and flat within a wave-length of light; plane-parallel crystal plates can also be ground normal to any given optical direction. The instrument is based on the theodolite principle, but it is essentially different in design and construction from earlier types; certain features of the Goldschmidt design have, however, been incorporated in it. A. W.

298. *New Form of Flicker Photometer.* **H. E. Ives** and **E. J. Brady.** (Phys. Rev. 4. pp. 222–227, Sept., 1914. El. World, 64. pp. 919–920, Nov. 7, 1914. Abstract.)—To ensure satisfactory working of a flicker photometer (1) the dividing line between the two fields which are alternated should be a line without breadth, (2) the speed of alternation should be accurately adjustable, and (3) it should be possible to vary the relative brightness of the two fields quickly over a wide range with a minimum of physical effort. The author describes an instrument adapted to fulfil these requirements. The division between the fields is obtained by using a double prism similar in principle to that used in the Lummer-Brodhun photometer. One of the prism faces is mirrored, and portions of this mirror-surface are removed with a sand blast. The other prism is then cemented on with Canada balsam. Thus a very fine line of division is obtained. The alternation is obtained by a rotating prism placed between the field and the observer's eye, so that the reflected and transmitted portions are seen in rapid succession. The rotation is achieved by driving from a series motor with a variable sliding resistance, and this, together with certain fixed resistances, gives the desirable range of speed. The third condition is conveniently fulfilled by inserting in the path of the rays from the comparison lamp two line-gratings, which can be revolved with respect to one another. The relation between the amount of light transmitted and the angle of rotation is approximately a straight line. The photometer is intended to be used on the double-weighing or substitution principle. J. S. D.

299. *Theory of the Flicker Photometer.* **H. E. Ives** and **E. F. Kingsbury.** (Phil. Mag. 28. pp. 708–728, Nov., 1914.)—An experimental study of the flicker photometer was recently made by Ives [Abs. 393 (1913)], when the relation between brightness and "critical speed of flicker" was discussed. These results are summarised again, essential points being the existence of a reversed Purkinje-effect, and a difference in the relation mentioned above, in the case of red, green, and blue light, which is shown diagrammatically. The author now seeks to explain these phenomena by considering the visual apparatus to possess coefficients of conductivity and capacity, as represented by the constant (diffusivity) in the Fourier conduction equation. This idea is developed mathematically, and periodic curves are drawn illustrating the combined effect of colour stimuli which are out of phase. It is contended that the theory explains the reversed Purkinje-effect, and that it sheds light on the distinction between "colour-flicker" and "brightness-flicker," of which all observers are conscious in working with the flicker photometer. J. S. D.

300. *Influence of Diffraction on the Formation of Optical Images.* **J. W. Gordon.** (Phot. J. 54. pp. 306–337, Dec., 1914. Seventeenth Traill Taylor Lecture.)—Gives an historical sketch of the theory of diffraction, and discusses in some detail the diffraction patterns in optical images obtained with apertures of numerous different shapes. A. W.

301. *Photography : Three-colour Work.* **E. H. Gamble.** (Phot. J. 54. pp. 359–362 ; Disc. 362–369, Dec. 19, 1914.)—A method for enhancing greens by projection of green light upon the screen image through an appropriate negative and photographing the screen image so intensified by optical means. A. D.

302. *Colour Analyses of Two Component Mixtures.* **L. A. Jones.** (Phys. Rev. 4. pp. 454–466, Nov., 1914.)—The work dealt with in this paper was carried out in order to determine definitely the hue and purity of all the colours that it is possible to produce with a given pair of colour-filters by using them as sectors in an adjustable rotating disc, and altering the relative sizes or densities of the filters, a beam of white light being sent through the disc. Many of the possible combinations that can be obtained with a given pair of filters were investigated, and the resulting colours examined with a colorimeter of the monochromatic type. The conclusions to be drawn from the results obtained are as follows :—It is not possible with two filters that are complementary, or nearly so, to produce mixtures that show appreciable colour of more than two dominant hues, those hues being the dominant hues of the filters themselves. With a pair of filters of the tri-colour type it is possible to produce mixtures having low percentage white values, and of all hues lying between the dominant hues of the filters themselves ; but no mixture can be produced with such a pair that has a high percentage white value. This method of analysis affords a good means of showing how closely any two filters approach the condition of being complementary to each other. The percentage white curve, in case the filters are exactly complementary, must reach a maximum of 100 %, and at the abscissa value corresponding to this maximum the hue curve must change abruptly from the dominant hue of one of the components to that of the other. The results are confined to mixtures produced by red and orange with blue and blue-green. Further work with other colours remains to be done. A. W.

303. *Use of Tinted Screens to produce Contrast Effect in Photometers.* **A. Boltzmann.** (Phys. Zeitschr. 15. pp. 718–720, July 15, 1914.)—It has been found by Lummer and Brodhun that greater sensitiveness in a photometer can be attained by making use of the "contrast" effect instead of "equality of brightness." The author describes some experiments, in which four observers participated, designed to test the comparative sensitiveness of the two methods with a Lummer-Brodhun photometer. Besides the ordinary arrangement special varying contrast could be introduced into the field by substituting for the magnesia screen paper divided into areas tinted with various intensities. The eyes of one observer showed throughout considerably lower sensitiveness than those of the other three ; it also appears that the best form of photometric field to secure sensitiveness depends to some extent on the subjective qualities of the observer person using the photometer. But in all cases the contrast effect gave better results than the equality-of-brightness arrangement. The degree of contrast experimented with varied from

3·42 to 11·82 %, and the best value (at 6·70 % contrast) appears to lie very near to that adopted by Lummer and Brodhun. The following table gives the mean of the results obtained by the other three observers—

LUMMER-BRODHUN PHOTOMETER.

	No Contrast.	Ordinary Contrast Arrangement.	Special Divided Field (No. 3).
Degree of contrast	—	6·82 %	6·70 %
Mean percentage error	0·41	0·27	0·23

J. S. D.

304. *Flame Standards in Photometry.* **E. B. Rosa** and **E. C. Crittenden.** (Bureau of Standards, Bull. 10. pp. 557–595, July 15, 1914.)—A revision of a paper published in 1911 [see Abs. 333 (1911)]. The authors state that more recent developments have not materially changed the conclusions then stated, but the present paper gives particulars of many additional measurements, covering in all about 80 pentane lamps. The Vernon Harcourt lamp is stated to have stood the test of use, and remains the most practical flame standard we have. Nevertheless, the results obtained indicate that in its present form the pentane lamp cannot be considered as a reproducible primary standard, its value in this respect being decidedly less than that of the Hefner lamp. If the principles of the present lamp are to be applied to the development of a primary standard, lamps should be built to very exact specifications, and be operated within very narrow limits of temperature and humidity, with pentane satisfying very rigorous requirements as to density and boiling-point and an atmosphere maintained constant as to its oxygen-content. With a view of contributing something to the working out of such precise specifications further investigations will be made. F. E. S.

305. *Molecular Extinctions of Saturated Aliphatic Ketones.* **F. O. Rice.** (Roy. Soc., Proc. Ser. A. 91. pp. 76–92, Dec. 1, 1914.)—The author has carried out quantitative measurements of the ultra-violet absorption of a large number of aliphatic ketones. All the ketones used were rigorously purified by chemical means, and no measurements were recorded until the liquids were found to be diactinic beyond λ2400 Å.U., and gave no reduction when shaken up with dilute permanganate for 15 minutes. The pure liquids on examination show geometrically similar extinction curves, those of the general type $CH_3 . CO . CH_2 . CH_2R$ having the centre of the band at 2790 Å., and those of the type $R . CH_2 . CH_2 . CO . CH_2 . CH_2R$ at 2820 Å., R being a saturated alkyl radical. Substitution in a hydrogen position by methyl shifts the maximum 20 Å.U. redwards, but if on substitution in this position an iso- or a tertiary grouping is formed the shifts are respectively 50 and 30 units. With the exception of acetone and methyl ethyl ketone all the members examined give the same max. molecular extinction, 21·2. These two exceptions are probably slightly associated into diactinic molecules, and on this assumption using their max. extinction values, 17·1 and 19·4 respectively, the factors of association are shown to be 1·24 and 1·09. The former value agrees remarkably well with that observed from surface-tension measurements by Ramsay and Shields. In general behaviour as regards absorption the ketones show great

analogy to their behaviour in magnetic rotation phenomena. The author points out the considerable support that his results furnish towards Baly's conception of electromagnetic force-fields as the seat of absorption phenomena. C. S. G.

306. *Polarimetry.* (Bureau of Standards, Circ. No. 44. [140 pp.], Washington, 1914.)—This circular, which supersedes Circular No. 12, forms a comprehensive monograph on the subject, and should be consulted by those interested. A special form of white-light polariscope built for the Bureau is described; it is double quartz wedge compensating and possesses adjustable sensibility. Temperature corrections and control are fully discussed. L. H. W.

307. *Absorption and Resonance of Monochromatic Rays in Helium.* **F. Paschen.** (Ann. d. Physik, 45. 5. pp. 625–656, Oct. 15, 1914.)—Helium, when excited by a weak current in a Geissler tube, absorbs the rays λλ10830 and 20582 Å.U. and exhibits resonance for λ10830. The slightest impurity, particularly of hydrogen, lessens the absorption, and the special precaution of removing this impurity with small amounts of pure electrolytic oxygen must be carried out frequently to maintain the absorption at a maximum. The ray at λ10830 is composed of a strong principal component of λ10830·32 and a weaker satellite at λ10829·11. Absorption is greater in the case of the stronger component, and on account of the lesser intensity of the satellite in the exciting light the comparative resonance intensity of the latter might be expected to be weakened. Such is not the case, however, as the relative intensities of the resonance rays are the same as originally. Thus the light absorbed by the principal component must be capable of exciting resonance in the weaker component—a result opposed to that found by Wood and Dunoyer for the D-lines of sodium vapour. The resonance has exactly the same character and wave-length as the exciting light. Moreover, by a simple arrangement, it is shown that all the absorbed light reappears as resonance light, so that the helium resonator conforms to Planck's theoretical electrical resonator. Lower limits to the temperature of the ray at λ10830 Å.U. when excited by a Nernst lamp are placed at 7900–9600° abs. C. S. G.

308. *Structure of the Absorption Lines D_1 and D_2.* **G. J. Elias.** (K. Akad. Amsterdam, Proc. 17. pp. 720–731, Dec. 24, 1914.)—From phenomena observed by Mlle. G. v. Ubisch during the investigation of the state of polarisation of light emitted by a sodium flame in a magnetic field after it had passed through a tube filled with absorbing Na-vapour, she infers that the wave-length, for which the absorption of the vapour is a maximum, depends on its temperature, and in such a way that on rise of temperature a displacement towards the red takes place. The amount of this at 270° C. would be about 0·17 Å. unit with respect to the emission line. Experiments now described show that the absorption lines D_1 and D_2 are both double, the two maxima of absorption being somewhat sharper for D_1 than D_2, and the distance apart of the maxima is smaller for D_1 than for D_2 under the same conditions. These distances, however, are variable, many factors producing a change. For example, the distance apart of the maxima for the light from the negative carbon of the arc is much larger (about twice as large as a rule) than for the light from the positive carbon. The experiments tend to the conclusion that the distance of the absorption maxima is closely connected with the density of the vapour, and that the splitting-up increases with increasing density.

That what has been observed is chiefly an effect of density, and not in the first place a temperature effect, is supported by the fact that the influence of soda sprayed into the arc is for the greater part the same as that of absorbing Na-vapour at a much lower temperature. The temperature may have some effect, but probably this is only slight. The experiments do not appear to have any connection with the displacement of the maxima due to change of temperature, but it seems that the correct interpretation of Mlle. v. Ubisch's observations would be very intricate, and many more data would be required for it. A. W.

309. *Regularity in the Spectrum of Lanthanum.* **E. Paulson.** (Ann. d. Physik, 45. 8. pp. 1203–1208, Dec. 3, 1914.)—Following on similar work on the spectra of scandium, yttrium, and lutetium, the author now shows that a regularity exists in the spectrum of lanthanum. The lines between λλ3010·92 and 6671·67 Å.U. may be arranged into 16 groups each containing 6 lines, such that the 5 frequency-differences between adjacent pairs in each group, commencing with the redmost line, have the values: 2977·86, 659·00, 696·80, 879·18, and 1016·32. In some groups one or two members may not appear, and when this is the case the frequency-difference between lines on either side of the vacancy is the sum of the two differences which would normally appear. C. S. G.

310. *Mass and Velocity of α-Particles from Radio-active Substances.* **E. Rutherford** and **H. Robinson.** (Phil. Mag. 28. pp. 552–572, Oct., 1914. Paper read before the Wiener Akad. der Wissensch., Oct., 1913.)—A considerable discrepancy exists between the values of E/m for the α-particle deduced from radio-active measurements and the theoretical value for the helium atom, deduced from the atomic and electrochemical data. Thus the experimental value of E/m for the α-particle is 5070, whilst the theoretical value of E/m for the helium atom carrying two unit charges should be 4826. For this and several other important reasons mentioned, the authors have undertaken a very careful investigation of the values of E/m for α-particles. To determine the quantities E/m and v, the deflections of a narrow pencil of α-rays have been measured in both magnetic and electric fields *in vacuo* by the photographic method. In the experiments on magnetic deflection of the α-rays a thin film of radium C was employed as a source. The theory of the magnetic deflection of an α-particle in a field which varies from point to point is given, and it is shown that the effect of variability of the field can be taken into account by deducing a mean effective field which would produce the same deflection. Slight variations of magnetic field over regions very near the source and the photographic plate will only involve small corrections; but it is important to have the field as uniform as possible near the slit.

By a special experimental arrangement in which the photographic plate was fixed 50 cm. from the slit, and 85 cm. from the source of α-rays, an electrostatic deflection of more than 1 cm. on reversal was attained. An electrostatic field of about 2000 volts could be maintained by a battery of cadmium cells—carefully calibrated by direct comparison with two Weston standard cells. Excellent photographs are shown of both magnetic and electrostatic deflections of the α-rays from a source of emanation (with RaA and RaC) in an α-ray tube. The advantages and disadvantages of the use of an α-ray tube as a source, are discussed. The "lens action" of the tube in concentrating a large proportion of the radiation about a line of minimum deviation is clearly brought out both in the theoretical discussion and in the

photographs obtained experimentally. In the latter case the *inside* edges of the deflected beams are exceedingly sharply defined while the outer portions of the bands, which are produced by rays of all velocities down to the smallest which can affect the plate, tail off in a general blur.

For the unscreened α-particle from radium C the authors give the following values of E/m and v, from the results of their deflection experiments : $E/m = 4823$ e.m. units. $v = 1{\cdot}922 \times 10^9$ cm. per sec. Assuming this value of v (probably the most correct hitherto obtained) the initial velocity of expulsion of the α-particles from the various α-ray products can be deduced from Geiger's relation, viz., $v^3 = KR$, where R is the range of the α-particle in air. The results are included in the following table :—

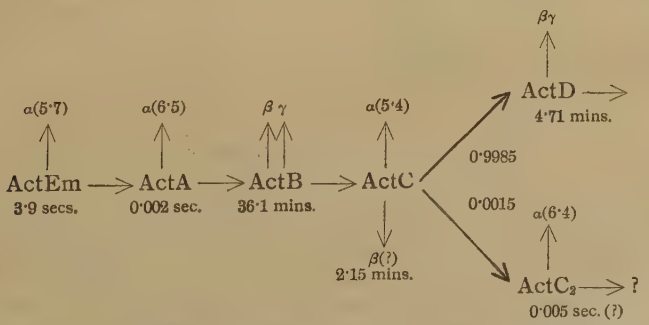
Substance.	Range of α-Ray in air at 15° C. and 76 cm.	Velocity in cm./sec. $= k\sqrt[3]{\text{range}}$.	$\frac{mv}{E}$ { electromagnetic units.$^{-1}$	$\frac{mv^2}{E} = \frac{\text{Energy.}}{e}$
Ur_1	2·50 cm.	$1{\cdot}37 \times 10^9$	$2{\cdot}84 \times 10^5$	$3{\cdot}88 \times 10^{14}$
Ur_2	2·90	1·44	2·98	4·28
Ionium	3·00	1·45	3·01	4·38
Ra	3·30	1·50	3·11	4·67
RaEm	4·16	1·62	3·36	5·44
RaA	4·75	1·69	3·51	5·95
RaC	6·94	1·92	3·985	7·66
RaF	3·77	1·57	3·25	5·10
Th	2·72	$1{\cdot}41 \times 10^9$	$2{\cdot}92 \times 10^5$	$4{\cdot}10 \times 10^{14}$
RadioTh	3·87	1·58	3·28	5·19
ThX	4·30	1·64	3·40	5·57
ThEm	5·00	1·72	3·57	6·16
ThA	5·70	1·80	3·73	6·72
ThC_1	4·80	1·70	3·52	5·99
ThC_2	8·60	2·06	4·28	8·84
RadioAct	4·60	$1{\cdot}68 \times 10^9$	$3{\cdot}48 \times 10^5$	$5{\cdot}82 \times 10^{14}$
$ActX^1$	4·40	1·65	3·42	5·65
ActEm	5·70	1·80	3·73	6·72
ActA	6·50	1·88	3·90	7·33
ActC	5·40	1·77	3·66	6·48

It has been calculated that the heating effect to be ascribed to the kinetic energy of the α-particles expelled from radium, is about 7 per cent. smaller than the value measured experimentally. It is consequently concluded that a small part of the heat emission from radium is to be ascribed to other causes. No evidence has been found that particles differing in mass or charge from the α-particle are emitted from an α-ray tube. A. B. W.

311. *Distribution of Active Deposit of Radium in Electric Fields.* **H. P. Walmsley.** (Phil. Mag. 28. pp. 539–552, Oct., 1914.)—In a previous paper the author has shown that under suitable conditions practically the whole of the active deposit from actinium emanation is concentrated on the kathode, but in the case of radium there always appeared from 5 to 10 % on the anode. Work of Wellisch and Bronson [Abs. 1039 (1912)] has confirmed the view that the case of radium is anomalous. In the present paper experiments dealing with this anomaly are described. The variation of anode and kathode activity with field strength is the first point investigated. It is shown that the distribution of the active deposit of Ra between the electrodes is independent

of the concentration of the emanation for small quantities, but depends on the dimensions of the apparatus. The percentage of positively charged active deposit collected by the kathode, increases with the applied field to a maximum, but there is always collected on the anode a certain amount of activity which is independent of the applied potential. To test whether the anode activity arises in some way by absorption of emanation by the metallic electrode, the anode activities collected by rods of different metals are compared. The results show that the nature of the metal has very little influence on the anode activity, although slight differences are observed due to absorption of emanation by the anode, this effect being most pronounced in the case of lead. The observations indicate, however, that absorption of emanation is quite insufficient to account for the anode activity. A direct determination of the variation of anode activity with area of electrodes is undertaken with a view to finding out the ratio of uncharged to negatively-charged active deposit, since the limiting value to which the anode activity tends when the area of its surface becomes infinitesimally small gives the amount of negatively-charged deposit. It is shown that this limiting value must be extremely small, thus proving conclusively that no negatively-charged active deposit carriers are formed. A table of results it given which shows that the anode activity using high potentials (1000 volts) is apparently collected on wires of different sizes in exactly the same way as when there is no field between the electrodes. Thus the anode deposit appears to be due solely to diffusion of uncharged active matter. It is also shown that no secondary effect after the deposition of RaA on the electrodes is responsible for the observed anode activity. In conclusion, the author compares the results obtained with those of similar experiments with actinium. The behaviour of radium and actinium active deposits in electric fields only differ in the *initial* activity which is found in the case of Ra. It is suggested that RaA, which is responsible for this initial activity, is capable of forming a partition between the metal surfaces and the space in the apparatus. A. B. W.

312. *Transformations of Actinium C.* **R. W. Varder** and **E. Marsden.** (Phil. Mag. 28. pp. 818–821, Dec., 1914.)—By analogy with the transformation in the active deposits of Th and Ra Marsden, Wilson, and Perkins [Abs. 100, 1429 (1914)] put forward the following scheme of disintegration for the actinium series:



The product $ActC_2$ was detected and measured by a scintillation method—counting the percentage of the total number of α-particles travelling beyond a distance of 5·4 cm. In the present experiments evidence of these long-range α-particles was sought for by an ionisation method, a magnetic field

being used to deflect the β-rays away from the ionisation chamber. Ionisation curves showing the existence of a product emitting α-particles of 6·4 cm. range are shown; thus the existence of a branch product in ActC, involving an emission of α-particles of range 6·45 cm. and 0·20 % of the atoms is verified. A. B. W.

313. *Excitation of γ-Rays by β-Rays.* **H. Richardson.** (Roy. Soc., Proc. 90. pp. 521–531, Aug. 1, 1914.)—Gray has shown that penetrating γ-rays are produced by β-rays of RaE when they fall on different materials, the amount of γ-radiation increasing with increase of atomic weight of the material [see Abs. 1144 (1911)]. The method adopted in Gray's experiments was, however, unsuitable for the detection of soft characteristic radiations such as those mentioned in previous papers by Rutherford and the author [Abs. 1675 (1913).] In consequence of some peculiar results obtained when RaC was deposited on nickel, it seemed important to examine in detail the nature of the radiation excited by the β- and γ-rays from RaB and RaC. The following table shows the results of an examination of the characteristic radiations of a large number of elements :—

Element.	Atomic Weight.	Mass Absorption Coefficient in Al. Series K.	Mass Absorption Coefficient in Al. Series L.	Corresponding Values of Mass Absorption Coefficients obtained by Barkla and Chapman.	
*Cobalt	58·9	72·6		71·6	
Nickel	61·3	58·5		59·1	
Copper	63·6	47·5		47·7	
Zinc	65·4	39·8		39·4	
*Arsenic	74·9	23·0		22·5	
Selenium	79·2	19·3		18·9	
†Bromine	79·9	16·7		16·4	
Molybdenum	96·0	4·8		4·7	
Silver	107·9	2·5		2·5	
Tin	119·0	1·6		1·57	
*Barium	137·4	0·9		0·8	
*Erbium	166·0				
Platinum	195·3		22·8		22·2
Gold	197·2		21·4		21·6
Lead	207·2		17·0		17·4
Bismuth	208·0		16·4		16·1
*Thorium	232·0		8·5		8·0
*Uranium	238·0		7·8		7·5

* Oxides used. † Thin layer of potassium bromide used.

Experiments are described in which the radiation excited by γ-rays alone was examined, but no certain evidence of the production of such radiations was obtained. Radium C, in addition to the penetrating type of radiation ($\mu = 0{\cdot}115$) emits also a small amount of soft γ-radiation similar in type to that emitted by RaB, and for which $\mu = 40$ in Al. The author also shows that the amount of γ-radiation excited by the α-rays of RaC is negligible compared with that excited by the β-rays. Two types of soft radiation are emitted when RaC is deposited on different materials : (a) the characteristic radiation of the material, excited by the β-rays of RaC, and (b) the soft radiation emitted by RaC. A. B. W.

HEAT.

314. *Thermal Expansion of Sodium, Potassium, and Lithium.* **A. Bernini** and **C. Cantoni.** (N. Cimento, 8. pp. 241–260, Oct., 1914.)—The authors briefly describe and criticise the methods employed and the results obtained in previous measurements of the thermal expansion of these metals. In their own determinations, which covered the range of temperature, 0 to 235°, use was made of a dilatometer containing vaseline oil, the expansion of the latter and that of the dilatometer being carefully measured beforehand. In each of the three cases, the expansion of the metal, in both the solid and the liquid state, is represented well by an equation of the second degree with respect to the temperature; the coefficients, α and β, of t and t^2 respectively, together with the other results obtained, are given in the following table :—

Metal.	Temperature Interval.	α.	β.	Increase of Volume on Fusion.	Melting-point.
Na Solid	0–78°	$0{\cdot}0_3 1816$	$0{\cdot}0_6 280$	2·031 %	97·6°
Na Liquid	100–235°	$0{\cdot}0_3 2599$	$0{\cdot}0_6 286$		
K Solid	0–56°	$0{\cdot}0_3 2112$	$0{\cdot}0_6 155$	2·44 %	62·04°
K Liquid	78–235°	$0{\cdot}0_3 2681$	$0{\cdot}0_6 210$		
Li Solid	0–178°	$0{\cdot}0_3 1535$	$0{\cdot}0_7 92$	1·51 %	180·1°
Li Liquid	182–235°	$0{\cdot}0_3 1743$	$0{\cdot}0_6 106$		

The values found for the thermal expansions are sensibly less than those obtained by earlier investigators, and those for Na and K are somewhat lower than Hackspill's recent numbers [Abs. 2015 (1914)]. The low value 1·50 %, given by the latter author for the change in volume of Na on fusion, is probably due to the presence of impurity, the melting-point given, namely 96·5°, being appreciably lower than that now obtained. The values given above are in accord with the relations established by L. Meyer (1880), Carnelley (1879), and Wiebe (1879), the coefficient of expansion increasing with increase of the atomic weight, with fall in the melting-point and with diminution of the specific heat of the metal.

T. H. P.

315. *Specific Heat of Solids.* II. **H. v. Jüptner.** (Zeitschr. Elektrochem. 20. pp. 10–18, 1914.)—In a former paper (ibid. 19. pp. 711–720, 1913) the author had arrived at a formula for the atomic heat of solids at constant volume under the assumption that the energy of oscillation has a definite limiting value (depending upon the frequency ν), and that this energy, below and above its limiting value ϵ', does not change by definite quanta, but at a steady rate. The formula is in good agreement with most observed values for all temperatures above $\beta\nu'$, where β is a universal constant, and ν' is defined by $\epsilon'/E_0 = \beta\nu'/T$ (E_0 being the mean energy). The lowest temperature for which the formula holds is 19·7° abs. for Pb, 68·3° for Cu, and 77·0° for Al. A few bodies deviate strongly, however : for diamond, *e.g.* the

agreement only becomes apparent above 381° abs. The author hence abandons his hypothesis of a limiting energy and assumes that a very small impulse may be sufficient to call forth atomic oscillations, but that the ratio between this impulse and the resulting energy of oscillation will only become constant for $T = \beta\nu'$. He modifies his co-ordinates and formulæ accordingly, arrives at an equation for the atomic heat between $T = \beta\nu'$ and $T = 0{\cdot}393\ \beta\nu'$, tests this with the aid of the experimental values of Nernst and Lindemann, and deduces a general formula for the mean atomic heat of solids for $T = \beta\nu'$ and higher temperatures; this formula is $C_v = 3R_\epsilon^{-\beta\nu'/T}$. Finally he gives tables for the true and the mean atomic heat (or heat capacity) of all solids in general, starting from $T = 0{\cdot}394\ \beta\nu'$ up to any temperature. The heat capacities below $T = \beta\nu'$ are so small that they may be neglected for practical purposes.

III. (Ibid. pp. 105–109, 1914.)—The above-mentioned equation fails for $T < \beta\nu'$. The author therefore re-discusses his assumptions and modifies them; the new equations hold also for the molecular heats of gases and the oscillation-energies of their atoms. H. B.

316. *Thermal Conductivity of Badly Conducting Solids.* **T. Barratt.** (Phys. Soc., Proc. 27. pp. 81–92; Disc. 92–93, Dec. 15, 1914.)—The thermal conductivities of a selection of non-metals at 20° and 100° C. have been determined by precisely the same method, and in the main with the same apparatus as was previously employed by the author in the determination of the thermal conductivities of some of the rarer metal and alloys [Abs. 1991 (1914)]. The substances treated were in the form of accurately turned cylinders placed in an enclosure at constant temperature. Measurements were made of the heat given electrically to one end of the cylinder, and of the temperature of this end and of the enclosure; the thermal conductivity is deduced from a simple formula developed in the previous paper. A table of results is given, which agree well with those obtained by Lees and others in cases where a direct comparison can be made. F. J. H.

317. *Temperature Distribution in an Incandescent Lamp-filament.* **A. G. Worthing.** (Phys. Rev. 4. pp. 524–534, Dec., 1914.)—A solution for the variation of temperature in a cylindrical incandescent lamp-filament has been obtained which agrees well with results obtained experimentally with a tungsten filament heated to a max. central temperature of 2315° K. The temperature distribution was obtained by a method similar in principle to the Holborn-Kurlbaum optical pyrometer, the filament of the pyrometer lamp being calibrated against a black body. The method of obtaining from the known distribution in one filament, that in another of different dimensions but having the same max. temperature is indicated, as is also that of obtaining the distribution in the same filament when heated to another max. temperature. F. J. H.

318. *Thermal Conductivities of Incandescent Lamp-filaments.* **A. G. Worthing.** (Phys. Rev. 4. pp. 535–543, Dec., 1914.)—A method of measuring the thermal conductivities of incandescent lamp-filaments mounted in evacuated chambers is described. It is the outcome of the study of energy losses in lamps by Hyde, Cady, and Worthing [Abs. 415B (1911)]. The method is based on optical pyrometry, details of which are given in a previous paper [see preceding Abs.]. The conductivities of tungsten, tantalum, and carbon in the region 1500° K. to 2500° K. have been obtained,

those for carbon agreeing well with results obtained by Hansen [Abs. 1018 (1910)]. Values of k/xT (where k and x are the thermal and electrical conductivities respectively, and T the absolute temperature) have been determined for the same substances in order to test the electron theory. Large temperature coefficients were obtained in contradiction to that theory. The equation $E = \sigma T^{\beta}$ has been found to hold in the case of tungsten for the relation between the radiation intensity E in watts/cm.^{2} and the abs. temperature T, where $\beta = 5{\cdot}35$ and $\sigma = 6{\cdot}2 \times 10^{-17}$. F. J. H.

319. *Relation between the Total Emissivity of Platinum and its Resistivity.* **P. D. Foote.** (Washington Acad. Sci., J. 5. pp. 1–7, 1915.)—The author has derived the relationship $E = 0{\cdot}5736\sqrt{r\mathrm{T}} - 0{\cdot}1769\ r\mathrm{T}$ between the total emissivity E of a metal, the volume resistivity r and the absolute temperature T. The relationship follows directly from the Maxwell theory of reflection and absorption. Measurements of the apparent temperatures of thin Pt strips were made by means of three Féry radiation pyrometers, the true temperatures being obtained from monochromatic ($\lambda = 0{\cdot}65\mu$) observations with a Holborn-Kurlbaum optical pyrometer. From these observations the total emissivity at various temperatures was calculated. These values plotted against temperature showed good agreement with the theoretical curve.

F. J. H.

320. *Further Experiments with Liquid Helium. Preliminary Determination of Specific Heat and Thermal Conductivity of Mercury at Liquid Helium Temperatures.* **H. K. Onnes** and **G. Holst.** (K. Akad. Amsterdam, Proc. 17. pp. 760–767, Dec. 24, 1914. Communication No. 142*c* from the Phys. Lab., Leiden.)—In view of the discontinuity in the electrical resistance of mercury at 479° K., measurements of the specific heat and thermal conductivity have been undertaken. None of the thermo-couples examined were found to be suitable for thermometric purposes at the very low temperatures employed, but the values of the thermoelectric forces of a number of metals against copper are given for temperatures ranging from 81° K. to 2·26° K. Resistance thermometers of constantan and manganin give, however, good results. The specific heat of mercury was determined by heating electrically a small block of the solid metal hanging freely in a high vacuum, and by measuring the rise of temperature which it undergoes. The mean values of the specific heat, which are accurate to within about 10%, are 0·00142 cal. per degree K. at 4·26–6·48° K. and 0·000534 cal. per degree K. at 2·93–3·97° K. The conclusion is drawn that the specific heat of mercury exhibits no peculiarity at the point of discontinuity in the electrical resistance. The above results are in moderately good agreement with those obtained by F. Pollitzer [Abs. 366 (1911)] at somewhat higher temperatures. For the thermal conductivity of mercury the following mean values are found : $k =$ 0·27 cal. per cm. per sec. at 4·5–5·1° K. and $k = 0{\cdot}40$ cal. per cm. per sec. at 3·7–3·9° K. ; here, too, no discontinuity occurs at 4·19 K. T. H. P.

321. *Fixed Points in Thermometry between* 100° *and* 400°. *Vapour Tensions of Naphthalene, Water, and Benzophenone.* I. *Naphthalene.* **J. M. Crafts.** (Journ. Chimie Physique, 11. pp. 429–477, 1913.)—Absolute stability is almost more important for thermometric standards than absolute purity even. Of many substances tried, alcohols, esters, hydrocarbons, etc., only water, naphthalene, and benzophenone are sufficiently stable ; mercury is too difficult to deal with. Water is absolutely stable between 70° and 170°. Naphthalene, purified

by fractional crystallisation, retained its boiling-point constant during continued boiling for 12 months ; the point was 218·25, 218·46, 219·09° on different mercury thermometers. The corrected boiling-point for Boston latitude, 42° 21′ N., at 28 m. above sea-level and 760·00 mm. is 218·06°. The investigation has been conducted since 1910 in the Massachusetts Institute of Technology ; the apparatus, the special ebullioscope, etc., used are fully described. A complete series of pressure boiling-point values for naphthalene has been obtained by direct comparison with a constant-volume nitrogen thermometer between 231·16 and 2149·37 mm., the corresponding boiling-points being + 171·23° and 269·51°; a formula covers this whole range. The temperature in the vapour space did not vary by more than 0·01°. Sensitive mercury thermometer should not be used for determining temperature difference exceeding that value, 0·01°. Pressures are determined with the aid of an open-type manometer and of a siphon barometer, the verniers of which are joined to platinum contact points. The bulb of the thermometer is of the same dimensions as the whole barometer, the temperature of the mercury of which is to be determined, and the fixed points (0 and 100°) are re-tested after each measurement. H. B.

322. *New Formulæ for Calculating the Cubic Expansion of Water.* **P. H. Hofbauer.** (Zeitschr. Phys. Chem. 84. pp. 762–763, Oct. 7, 1913.)—From various observations, which he does not specify, the author deduces one formula covering the range 0° to 40°, and another, covering the range 50° to 100° ; modified formulæ are also given. The values agree with experimental determinations to the fifth decimal. The quantities in his formulæ are : θ the absolute temperature, v the corresponding volume, and e the logarithmic base. He uses a peculiar notation for powers, writing, *e.g.*, ^{-1}e instead of $e^{1/e}$. H. B.

323. *New Thermochemical Method for subdividing accurately a given Interval on the Thermometer Scale.* **T. W. Richards** and **T. Thorvaldson.** (Am. Chem. Soc., J. 37. pp. 81–86, Jan., 1915.)—A new method is described for subdividing accurately any given interval on the thermometer scale. The method depends on carrying out a reaction in a calorimeter at various temperatures, and in such a way that the final temperature of one measurement is the initial temperature of the next, thus covering the whole interval to be investigated. The reaction chosen was the heat of dilution of hydrochloric acid, since it is easily measured, its magnitude is easily regulated, and the nature of the heat-capacity problem involved is comparatively simple. The acid was diluted calorimetrically in an apparatus previously described in detail (Richards, Rowe, and Burgess) [Abs. 415 (1911)]. By choosing varying initial concentrations of acid and varying final concentrations, a temperature-change anywhere from a few thousandths to several tenths of a degree can be obtained at will. Allowance must, of course, be made for the temperature coefficient of the reaction, and for other factors dependent upon changing heat-capacity. Details are given of the method of procedure, in the case of the calibration of a thermometer over the interval of temperature from 16° to 20°, sixteen successive temperature increments during dilution being measured. The results obtained are very satisfactory, and the method is put forward as peculiarly suitable for the standardisation of short ranges, such as those used in thermochemistry. T. S. P.

324. *Diffraction Errors in the Holborn-Kurlbaum Optical Pyrometer.* **A. G. Worthing** and **W. E. Forsythe.** (Phys. Rev. 4. pp. 163–176, Sept., 1914.)

—In some experiments with the Holborn-Kurlbaum pyrometer differences of about 40° in the temperature of a filament at 2300° K. were noted. Experiments were made to determine the explanation, and it was shown that the ratio between brightness of pyrometer filament and background varied considerably according to size of filament and the angle of the entrance cone of light (α). In some cases errors as great as 60 % were noted. The author describes in detail the apparatus used and the experiments conducted leading to this result. The errors appear to be due to diffraction at the filament of the pyrometer lamp of the light from the background. Large pyrometer filaments and large values for α tend to make the filament appear less bright than the background image ; small filaments and small values for α have a converse effect. The author makes a series of suggestions as to precautions which should be adopted in order to avoid these errors, *e.g.* that the sources to be studied should be used as a background and not as pyrometer filaments ; that a single pyrometer filament should be used throughout experiments ; that the background image should be large in comparison with the pyrometer filament. Finally, the possible effect of such errors on some previously published researches is briefly discussed. J. S. D.

325. *Vapour-pressure Curves of Phosphorus.* II. **A. Smits** and **S. C. Bokhorst.** (K. Akad. Amsterdam, Proc. 17. pp. 678–680, Nov. 27, 1914.)—Further investigations of the red and violet modifications of phosphorus [Abs. 1554 (1914)] shows that the supposed point of transition between the two forms does not exist, and that only one stable solid modification of the phosphorus has been found, this being violet in the coarsely crystalline state, but red when more finely divided. When the heating is protracted, the vapour pressures of different preparations of phosphorus approach values lying on a continuous curve, but under certain conditions an apparent discontinuity may arise as the result of too rapid heating. The results furnish confirmation of the theory of allotropy, since they lead to the conclusion that the stable red or violet modification of phosphorus is really complex, and consists of at least two components differing greatly in volatility. The term red phosphorus is retained for this stable form, although in its coarser form this has a violet colour. The values of the vapour pressure at temperatures between 300° and 589·5° are given in tabular and curve form. T. H. P.

326. *Lowering of the Freezing-point in consequence of an Elastic Deformation.* **G. J. Elias.** (K. Akad. Amsterdam, Proc. 17. pp. 732–745, Dec. 24, 1914.)—A mathematical treatment. A. W.

327. *Theoretical Study of Machines for the Liquefaction of Gases.* **H. Brot.** (Soc. Ing. Civils de France, Bull. 67. pp. 304–350, 1914.)—After describing the principles of the methods originally employed by Linde and by Claude, the thermodynamics of the subject is discussed, as also the conditions for the maximum production of cold. Certain later improvements in Claude's apparatus are finally considered. L. H. W.

328. *Electron Theory and Gas Molecule Distribution in Field of Force.* **O. W. Richardson.** (Phil. Mag. 28. pp. 633–647, Nov., 1914.)—According to Newtonian dynamics, $n_1/n_2 = e^{-(w_1-w_2)/RT}$, where n_1 and n_2 are the concentrations of the molecules at points where the potential energies of a molecule are w_1 and w_2 respectively, and R is the gas constant reckoned for one molecule. According to the quantum theories, this equation expresses

merely a high temperature limiting case of a more general law. The author takes Keesom's equations [Abs. 288 (1914)] as a starting-point from which to derive such a law. These equations depend on the assumptions : (1) That the heat-energy of the gas can be analysed into the vibrations in its elastic spectrum, and that the entropy of this system of vibrations can be calculated according to the method given by Planck ; (2) that the elastic spectrum is limited by the number of molecules according to Debye's principles ; (3) that Planck's hypothesis of zero-point energy holds good ; (4) that the interchange of energy between gas and radiation is by quanta, and that the corresponding frequencies are twice as great in the gas as in the radiation, in accordance with the principle that the pressure exerted by a given radiation has twice its frequency ; (5) that the velocity of the elastic vibrations is proportional to the square root of the energy of the corresponding vibration. Some support of Keesom's conclusions has been obtained from the equation of state of helium at very low temperatures, and in some other directions (5) should be a valid approximation at reasonably high temperatures, and its validity at low temperatures might possibly be capable of experimental investigation. A gas is then considered in equilibrium in a field of force for T constant, the resultant force on a molecule at any point being R(= X, Y, Z). The differences of the potential function of R for any two points then satisfy the equation—

$$w_1 - w_2 = -\int_2^1 X\,dx + Y\,dy + Z\,dz = -\int_2^1 \frac{V}{N}\,dp,$$

where N is Avogadro's constant, and V is the volume of a gramme-molecule of the gas. Now p is expressible as a function of V and T, and therefore of w and T only, so that the results will be independent of the geometrical distribution of the field of force. The above equation is then integrated by aid of Keesom's equations, and $w_1 - w_2$ is finally expressed as a function of V_1, V_2, and T, by an equation involving in addition only the universal constants k_1, N, and R, and the molecular weight M of the gas. In general the relation obtained is too complex for other than graphical solutions ; but there are three comparatively simple cases : (1) When x_1 and x_2 are both small, corresponding either to small densities or to high temperatures or to both these conditions. The solution then reduces to that of Newton dynamics. (2) When x_1 and x_2 are both large, corresponding either to high densities or to low temperatures or to a combination of these conditions, the solution becomes—

$$w_1 - w_2 = \frac{15}{16}\frac{R}{c}\left(V_2^{-\frac{2}{3}} - V_1^{-\frac{2}{3}}\right) + \frac{\pi^4}{5} R c^3 T^4 (V_2^2 - V_1^2),$$

where $c = 8/5 \,.\, MR/Nk^2 \,.\, (4\pi/9N)^{2/3}$. The terms neglected in this solution involve e^{-x_1}, e^{-x_2}, and their positive integral powers. (3) When x_1 is very large and x_2 is very small, *e.g.* in equilibrium between two phases of a gas differing enormously in concentration, the solution becomes $n_2 = NV_2^{-1}$. After showing the applicability of his procedure to the theory of thermoelectric phenomena, the author develops some formulæ which seemed to promise a crucial test of the theory in connection with the emission of electrons from hot bodies. For the Maxwellian distribution of kinetic energy among the emitted electrons is required by his theory and established experimentally, while, in the case of the internal free electrons, the distribution, while Maxwellian according to the classical dynamics, should, on the author's theory, be governed by the considerations of the quantum theory. Unfortu-

nately the requisite experimental determinations could not be sufficiently disentangled from the effects of secondary phenomena to give decisive results.
G. W. DE T.

329. *Statistical Relations of Radiant Energy.* **G. H. Livens.** (Phil. Mag. 28. pp. 648–664, Nov., 1914.)—The author here presents considerations which suggest that no difficulties of a fundamental nature are involved in Planck's theory, and that it does not necessarily imply any new physical basis for radiation phenomena. Planck's method, however, of arriving at his theory does, as Lorentz has pointed out, involve the assumption of a finite atomic structure for the energy in radiation. His theory undoubtedly represents the experimental facts, while the Rayleigh and Jeans formula derived from ordinary considerations does not. In both the validity of the Fourier analysis is assumed, and this depends on the assumption that the radiation function contains a finite number of singularities only. And it is difficult to avoid the conclusion that the spectrum of thermal radiation must have perfect theoretical continuity. This consideration does not materially affect the conclusions of Gouy and Rayleigh regarding the origin of the periodicity in sunlight. Neither does it remove the problem beyond the power of analysis, considering that we are concerned merely with averages, and that for the purposes of a statistical theory every possible oscillation with a wave-length in a given small range $\delta\lambda$ is practically identical with all the others ; so that it suffices, as Planck and Jeans have done, to examine some simple system with one oscillation of each type in each specified range, and multiply by a very large number N_λ the amount of energy deduced as corresponding to wave-length in the specified range for the simple system. This is practically equivalent to superposing a vast number of practically identical systems, differing enough, however, to fill out each small range so as to give a continuous spectrum.

Considering Rayleigh's simple illustrative problem of energy partition between the vibrations of a stretched string, the author points out that the procedure of Rayleigh and Jeans omits to consider the necessary restrictions on the values of the coefficients in the Fourier series for the kinetic and potential energy. The general conditions of convergency are too general and indefinite, and the author adopts the arbitrary procedure of applying the simplest possible convergency tests in ascending order of simplicity, and assuming that the first, that is the simplest, test found to fit experimental facts is probably the correct one. This procedure is shown to lead to a formula identical with Planck's in probably all attainable regions of the spectrum, without any assumption of peculiar physical structure of the molecule, electron, or ether. G. W. DE T.

SOUND.

330. *Sound Intensity and Thermal Conductivity of Gases.* II. **K. Heindlhofer.** (Ann. d. Physik, 45. 2. pp. 259–282, Sept. 1, 1914.)—In the first part under the like title [Abs. 886 (1912)] was given an absolute method for measuring sound intensity, the principle being dependent on the determination of a temperature. In the field of the sound a gold leaf was exposed to the warming of the wave compression, and this permitted an inference as to the absolute intensity of the sound. The same main idea permitted also the determination of the thermal conductivity of the gases used, if the frequency of the sinusoidal compression, thickness of gold leaf and its temperature variations are known. In the present paper part of the theory previously developed is corrected. This later theory is then experimentally confirmed for known pressure-differences with frequencies from 5 to 32 per sec. The temperature-changes of the gold leaf were estimated by the corresponding changes in its electric resistance. E. H. B.

331. *Change of Frequency of Sounding Bodies in Gases.* **A. Kalähne.** (Ann. d. Physik, 45. 3. pp. 321–352, Sept. 15, 1914.)—An experimental research of which the following are the chief points :—(1) The decrease of frequency of slightly vibrating bodies by the presence of the different gases surrounding them was investigated. (2) The sounding bodies used were thin-walled Al tubes fixed at two nodes and vibrating transversely like solid bars. (3) To a first approximation the change of frequency is proportional to the density of the gas and independent of the chemical nature of the gas. (4) Theory and experiment are in good accord in the case of this vibrating tube with gas inside and out. E. H. B.

332. *Phase-change Tones in Accord with the Resonance Theory of Helmholtz.* **F. A. Schulze.** (Ann. d. Physik, 45. 2. pp. 283–320, Sept. 1, 1914.)—The special sound phenomena called phase-change tones are here experimentally produced and controlled as follows : The sound from a tuning-fork by R. K. Koenig, passes along a tube which then branches into two slightly diverging tubes, the whole shaped like a capital Y. One of the branches has a telescopic sliding part to adjust its length. At the far end of each branch is a microphone put in circuit with a battery and transformer primary. The secondaries of each transformer are put through a commutator to a telephone transmitter. Thus, the tone of the spark may be heard in one phase (through one branch of the tube), or in another phase (through the other branch) at will ; or the phases may be repeatedly interchanged whenever desired by means of the commutator. The chief results may be briefly summarised as follows :—The experiments show that the sound phenomena heard on periodically and regularly changing the phase of a tone correspond completely with the consequences of the Ohm-Helmholtz resonance theory of audition. There appear in general the tones p and the variation-tones of higher order $p \mp u, p \mp 2u$, of which in special cases one may disappear, particularly the tone p itself by the phase-change π. A *phase-change tone* in the sense of the periodic theory does not exist. A tone of the pitch $2u$ is formed only as the difference of the two objective variation-tones $p - u$ and $p + u$. [See Abs. 1721 (1904) ; 1675 (1908).] E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

333. *Electrical Development during the formation of Water-drops.* **M. Aganin.** (Ann. d. Physik, 45. 7. pp. 1003–1012, Nov. 17, 1914.)—This paper is a record of investigations made to determine to what extent the actual splitting-up of a water mass into small drops is the cause of electrical separations. The subject is part of Lenard's fundamental work on "The Electricity of Waterfalls," and is exceedingly important from the meteorological standpoint. In the latter, Lenard came to the conclusion that the disruption of water in itself is inactive, but that the impact of the separated drops upon obstacles generates electrical action. The present author now seeks to find whether the disruption is without effect entirely, or whether very sensitive methods will be able to detect some electrical development. Many previous experimenters have demonstrated strong electrification of the liquid and surrounding atmosphere, but as the whole procedure is so exceedingly complex the final solution of the problem has not yet been determined. The effects observed must certainly be ascribed in part to the mutual impact of the drops on each other, and therefore this must first be subtracted before the disruptive influence can be ascertained. The work of Trübi and Bernolak is then considered, the latter having shown that the electrical development is intimately bound up with the formation of secondary drops. Further, when the secondary drop formation is great, some of these condense, an act which must be accompanied by electrification of the water and which would explain Bernolak's observation. The apparatus used was for the first experiments, that of Bernolak, and receives detailed description in the paper. The author noticed, however, that spray-formation always took place in the neighbourhood of the water exit, and accordingly most elaborate precautions were taken to remove this disturbing factor; details of these are given in full. Another cause of electrification may be the impact of the falling drops on the water surface in the collecting vessel, and this was established by J. J. Thomson's method, using methyl violet as indicator. Bernolak's work was thus shown to be invalidated on this account. Experimental details are then given of the means adopted to eliminate this factor. Several other precautions to eliminate possible disturbances and to increase the sensitiveness of the apparatus are described. The result arrived at is, that either the disruption produces no electrification, or that the effect is too small for detection by the apparatus employed, and supports Lenard's conclusions above referred to. [See next Abstract.] H. H. Ho.

334. *Electrical Effects accompanying the Fall of Water in Fine Jets.* **M. Aganin.** (Ann. d. Physik, 45. 7. pp. 1013–1038, Nov. 17, 1914.)—A continuation of Lenard's fundamental work on the "Electricity of Waterfalls." Lenard proved that the rebound of raindrops on the earth's surface charged the atmosphere to such an extent that the sign of the potential gradient could be affected. Later Lenard took up the study of the extent to which diminution of liquid surface could be a cause of electrical development. Since the formation of raindrops is due to the combination of mist nuclei of an average diam. of 0·02 mm., one single raindrop of 0·5 mm. diam. requires

more than 15,000 nuclei with a surface disappearance of about 18 mm.^{2} of free water surface. The electrical development consequent on this diminution must play a great part in any electrical phenomena due to rain, and the present author here records a quantitative study of this branch of the subject. Originally separate drops were experimentally investigated, but it was found impracticable to obtain a uniform supply of falling drops smaller than 0·8 mm. in diam. Much better results were given by fine water-jets formed by allowing water to flow out of very fine capillary tubes, when drops down to 0·4 mm. diam. were obtained. The electrical properties of these fine jets were then investigated. When the drops were allowed to impinge on a metallic surface, the electrification was found to be very variable, but more stable and stronger effects were obtained when the impact took place on a water surface. Full details are given of the apparatus used for this part of the work. A difficulty encountered was the presence of dust in the water, which would undoubtedly modify the electrical phenomena. Details are given of the means devised for reducing such disturbance to a minimum. The dependence of the impact effect on the length of the jet received special attention. It was found that the impact of one jet upon another produced a much smaller effect than the impact on still water, a result due to the electrification developed by the formation of bubbles. The structure of fine-water jets was next investigated for the purpose of throwing light on the relationship between the electrical effect and the length of the jet. Intermittent illumination by electric sparks was employed, and as a general result it was found that jet structure was extremely unstable in character. The electrification due to the coalescence of drops in the jet next received attention, and elaborate experimental details of this investigation are given. The study of jet structure showed that coalescence of the drops only occurred within a few cm. of the disintegration point, and in more remote sections of the jet the drops on impact were more often reflected. The variation of the electrometer indications with alterations in the jet length were therefore carefully studied : tables of results are given. The electrification due to the impact of a jet on a rigid surface was next studied with the object of finding the disturbing effect due to bubble formation when the impact takes place on a water surface. Finally the insufficiency of the electrification due to drop coalescence as an explanation of rain charge is shortly discussed. The following represent the general results obtained : (1) By the impact of thin jets on still water, very small air-bubbles are generated which strongly increase the electrification effect and explain the observed dependence of the electrical effect on the length of the jet. (2) The structure of fine jets is extremely complex. The drops depart from the unbroken section of the jet with different velocities, and, at the outset a coalescence takes place, while later the drops are reflected from each other and so scattered. (3) Coalescence in the upper part of a fine jet brings about an appreciable charging of the surrounding atmosphere. An electric field greatly influences the charge due to coalescence. (4) The smaller drops do not increase the electrification per cm.^{3} of water so much as the passage through of small gas-bubbles. (5) During rain-formation the electrification developed by the coalescence of mist nuclei is not sufficient to explain the electrical phenomena, unless the coalescence takes place in a strong electric field. H. H. Ho.

DISCHARGE AND OSCILLATIONS.

335. *Nature of the Photo-electric Phenomenon shown by Selenium.* **W. Del Regno.** (N. Cimento, 8. pp. 295–329, Oct., 1914.)—The author has made a

number of measurements to determine the varying sensitiveness of Se in the different regions of the spectrum of the exciting light. An improved cell has been devised in which the Pt electrode takes the form of a thin, uniform layer deposited by kathode disintegration on the Se plate. The cast Se was previously reheated for two hours at either 195–200° or 105–110°, cells of "soft" or "hard" type being thus obtained. The results attained are as follows :—The diminution of the resistance of selenium on illumination and its subsequent recovery in the dark are not instantaneous, but require a time varying with the experimental conditions. The velocity of diminution of the resistance is greater than that of recovery, and these velocities vary during the course of the phenomenon. The sensibility increases with the intensity of the exciting light, especially during the first moments, whilst with one and the same illumination the sensibility depends on the method employed in preparing the cell. Previous illumination of the cell diminishes its sensibility. The most efficacious rays are the red, the value of λ varying, with different lamps, from 0·76 to 0·70μ ; in other parts of the spectrum the effect is virtually non-existent. No trace was found of the maximum at $\lambda = 0{\cdot}8\,\mu$ noted by Brown and Seig [Abs. 1442 (1914)], whose results appear to be erroneous. The position of the maximum is not altered when the temperature of the lamp filament is changed. These facts seem to indicate that the phenomenon is one of pure resonance. T. H. P.

336. *Photoelectric Effect on Ultramicroscopic Metal Particles.* **E. Meyer and W. Gerlach.** (Ann. d. Physik, 45. 2. pp. 177–236, Sept. 1, 1914.)—Ultramicroscopic metallic particles are formed by the passage of an electric spark between suitable electrodes. These are then allowed to pass into a Millikan chamber and, by incidence of ultra-violet light, become photo-electrically sensitive. The fact that they are parting with electrons is detected by their behaviour in the chamber, which indicates they become more and more positive. An approximate theory of the phenomena is given. [See Abs. 139 (1914).] E. H. B.

337. *Ionisation of Platinum by Kathode Rays.* **N. Campbell.** (Phil. Mag. 28. pp. 286–302, Aug., 1914.)—Many investigators have shown [see Abs. 1711 (1913)] that when kathode rays fall on a metallic plate electrons leave the plate, the numbers and speed of these electrons depending on the speed of the incident rays. The observations made in these experiments are explained on the supposition that two distinct processes are involved : (1) the reflection of the incident rays ; (2) an excitation by them of secondary rays. The first process only is present when the speed of the incident rays is less than 11 volts ; the second then begins, and becomes of increasing importance as the speed increases until a maximum of 200 volts is passed. Observations on the production of "δ-rays" by α-rays, combined with other evidence, seem to indicate that the emission of the secondary rays by fast primary rays is a process analogous to the ionisation of a gas by such rays ; the critical speed, 11 volts, represents the "ionisation potential" of the metal, the maximum at 200 volts representing the speed of the rays which have max. ionising power. It is found that the ionisation potential varies considerably with the gas, while the "ionisation potential of metals" seems to be *independent of the metal ;* this at once suggests that the ionisation occurs, not in the atoms of the metal itself, but in the layer of gas (hydrogen, the same for all metals) condensed on the surface. The present paper gives the preliminary results of an attempt to determine the *true* ionisation potential

of the metal (freed from gases), the object being to throw some light on the difficult problem of the photoelectric effect. For a description of the methods of experiment the original paper must be consulted. The author summarises some of the more important results as follows :—"The ionisation produced by kathode rays in platinum can be reduced very greatly by continued heating *in vacuo* and in oxygen. At first the heating produces no effect, then it produces a large and sudden change followed by a very slow and long-continued change the end of which has not been reached. It is quite possible, or even probable, that ultimately a state would be reached in which the Pt would not be ionised at all by rays of less than 40 volts speed. The initial state of the metal can be restored by allowing kathode rays to fall on the metal with a speed of 100 volts in a pressure of gas not less than 0·01 mm. ; mere access to the metal of gases and vapours does not restore that condition quickly, if at all. When the initial condition is restored by action of kathode rays it is much less permanent than before ; the second state can be regained by a few minutes, instead of many hours, of heating." Experiments to show that there is no direct effect of temperature on the ionisation of the Pt are also described. In the discussion of the results obtained it appears that a fairly satisfactory explanation of the phenomena is supplied by the well-known views as to the contamination of metal surfaces with gas, this contamination being present in two forms : (*a*) gas condensed on the surface, (*b*) gas dissolved or "entangled" in the body of the metal. The research proves clearly the fact that the ionisation produced at a metal surface by kathode rays can be decreased very markedly by the same treatment which greatly reduces the thermionic and photoelectric effects. It is urged, in conclusion, that the results throw light on the experiments which have been described illustrating the abolition of the photoelectric effect when the surface of a metal is "cleaned," and that they destroy most of the reasons for holding that the prevalent theory of that effect is entirely incorrect. [*Errata.* Ibid. Dec., 1914.] A. B. W.

338. *Continuous-current Arc between Nickel Electrodes.* **A. Hagenbach** and **W. Frey.** (Archiv des Sci. 38. pp. 229–236, Oct., 1914.)—The authors describe observations made on an arc between Ni electrodes in an atmosphere of nitrogen at low pressure enclosed in an iron vessel. The anode was water-cooled. An ordinary arc using various currents and gas pressures was also employed. It is found that the p.d. between the electrodes varies with the time, the current being kept constant. The arc was started and the p.d., e, plotted against the length of the arc, l ; the measurements were repeated at intervals of 15 minutes. For the two forms of arc there is an increase in e, initially 115 volts, of about 6 volts in 30 mins. for the longer arcs (2·4 cm.) and 2 volts for the shorter (0·9 cm.), in which case the initial value is about 80 volts. The longer the arc the greater the rise in e. The influence of time is strongest during the first quarter of an hour ; afterwards it diminishes, and ceases after one hour. An attempt was next made to determine where this variation occurs. The potential in the arc itself was found by means of a carbon probe connected through a voltmeter to (1) the anode, (2) the kathode. Straight-line curves are found on plotting distance from electrode against p.d. of probe from electrode. The first series of measurements was taken immediately the arc was started and another at the end of 1 hour. When the potential of the probe is measured relative to that of the anode it is found that the curve obtained after 1 hour remains parallel to the first curve but all the potential differences are decreased by about 1 volt. By

extrapolation of the curve the anode-fall is 54 volts; the voltage across the arc being 120 initially, 130 volts after 1 hour. When the p.d. between probe and kathode is measured there is an increase of 10 volts after 1 hour for all positions of the probe. The inclination of the curves remaining the same it is concluded that the potentials in the arc itself do not vary, but that the kathode-fall varies with the time. Probably it is chiefly the heat-flow which varies with the time, being greater at the commencement. From Simon's theory of the arc we should therefore expect that the p.d. between the electrodes should decrease as the time increases, which is the opposite of what is observed. This discrepancy is discussed, and a possible explanation put forward. T. H.

339. *Rectilinear Oscillator.* **E. B. Wilson.** (Amer. Acad., Proc. 50. pp. 107–128, Oct., 1914.)—A mathematical discussion of the differential equations which may be used to represent the motions of Planck's rectilinear oscillator, a special feature of the work being that with certain forms of the equation the motion may reach a *point d'arrêt* at which the acceleration assumes an imaginary value. The equation which is discussed both qualitatively and quantitatively may be written—

$$m\frac{dx}{dt}\left(\frac{d^2x}{dt^2}+K^2x\right)=-\frac{2}{3}\frac{e^2}{c^3}\left(\frac{d^2x}{dt^2}\right)^2 \quad \ldots\ldots(1)$$

and this arises by the application of the principle of energy with the usual law of instantaneous radiation, and which would arise from the integrated form of the energy equation by the same reasoning as is applied, to obtain the equation—

$$m\left(\frac{d^2x}{dt^2}+K^2x\right)=\frac{2}{3}\frac{e^2}{c^3}\cdot\frac{d^3x}{dt^3} \quad \ldots\ldots(2).$$

One of the first inferences the author draws from his work is that whatever may be thought of the merit of (1) or (2), the Abraham-Planck-Rüdenberg derivation of (2) is without much mathematical or physical validity. The derivation of Lorentz and Ritz is not open to the same objections, for it proceeds directly from the retarded potentials to (2) through a series of approximations. The law of radiation which this equation states is that the rate of radiation is

$$m\frac{dx}{dt}\left(\frac{d^2x}{dt^2}+K^2x\right)=\frac{2e^2}{3c^3}\cdot\frac{dx}{dt}\cdot\frac{d^3x}{dt^3}, \quad \ldots\ldots(3)$$

which for oscillatory motions is nearly proportional to the square of the velocity and is physically nearly equivalent to a friction proportional to the velocity. The average rate of radiation is, of course, that which corresponds to that found by Hertz.

The author considers that the real interest of the present work lies in the general inferences or alternative inferential possibilities of importance to physical science which the discovery of the *point d'arrêt* may suggest. Various possible ways of escape from the *point d'arrêt* (or cusps in the space-time locus) are finally pointed out and briefly discussed. E. H. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

340. *Electric Resistance of Iron-Nickel Alloys.* **A. P. Schleicher** and **W. Guertler.** (Zeitschr. Elektrochem. 20. pp. 237–252, 1914.)—The

large number of previous researches on the magnetic properties suggested that the alloys can be divided into two classes : those containing more than 25 % Ni give the same transformation curves on heating and on cooling and are hence called reversible ; alloys with less than 25 % Ni are irreversible, there being considerable arrests, so that the temperatures at which transformations occur appear too high on the heating curves and too low on the cooling curves. Neither these investigations nor the dilatometric and resistance determinations really explained the complicated phenomena, which, in the authors' opinion, are caused by transformations in the series of solid solutions. These can be studied by resistance tests at very slow temperature-changes. For the present the experiments concern the alloys containing about 30 % Ni, about which there was most uncertainty. The material, wires of 35·25, 30·6, 25·2 % Ni, were supplied by Krupp, and the experiments made with aid from Siemens and Halske. The wire spirals are joined to copper rods and placed in tubes, 1 m. long, of Jena glass or Berlin porcelain (glazed inside and outside), in an electric furnace of Heraeus, a vacuum (0·0001 mm., generally 0·0005) being maintained at temperatures up to 1000° with the help of a Gaede pump ; an experiment lasts 8 or 9 hours. The hard-drawn wires gave first irregular curves, which became more regular. Selecting the most trustworthy of a large number of curves, it is found that perfect parallelism exists for the three alloys. All the alloys seem therefore to lie in the same homogeneous field of the condition diagram which extends upwards to various temperatures, to 900° for the 25 % Ni-alloy, to 700° for the 30 % Ni, and to 420° for the 35 % Ni. Since the resistance-changes, above the transformation temperature, are relatively small even in the case of the rich alloys, it is concluded that there will be another homogeneous field beyond the former, and that the transformation-range lies (at different temperatures for the different alloys) between the two fields.

H. B.

341. *Passage of Electricity at Contact Gaps, and Electron Atmospheres of Metals.* **F. Rother.** (Ann. d. Physik, 44. 8. pp. 1238–1272, Aug. 4, 1914. From Dissertation, Leipzig.)—An experimental research of which the chief results may be summarised as follows :—(1) An optical method is described by which the tiny gap between two balls, or *contacts*, could be made any very small measurable distance. (2) When this gap or distance between the *contacts* was less than a wave-length of light, even 1 volt would give a current. This was measured and found to be of the order 10^{-14} amp. (3) This measure of the current was obtained by use of an electrometer. (4) In connection with this a spherical condenser was used. (5) A special method of polishing is described which furnished satisfactory optically-good metallic surfaces. (6) The current passing across the small space between different metals was found to be different. In the case of the metal tested (gold and iridium) the better-conducting metal gave the better conducting gap. But the ratio of the gap conductivities was about 3 times that of the conductivities of the metals themselves. (7) From this difference of gap conductivities with different metals it is concluded that the conductivity in question is due to metal electrons. The phenomenon was not measurably different in air at atmospheric pressure and under a *vacuum* of about 0·5 mm. (8) An attempt to determine the conductance of this electron atmosphere in the gap showed that it varied with the distance between the *contacts*. The apparent conductivities of these atmospheres were of the order : for gold 10^{-14} and for iridium 10^{-15} (the ohm being the unit). [See Abs. 1385 (1911).] E. H. B.

342. *Potential Energy due to a Coil carrying a Current.* **A. Blondel.** (Comptes Rendus, 159. pp. 725–733, Nov. 30, 1914.)—Calculation of the potential energy of a coil carrying a constant current, which is being wound up in a magnetic field [Abs. 89 (1915)]. The field is in the direction of the axis of rotation and two cases are considered: (1) when the field is due to a magnet, or (2) to a second coil carrying a current. The case when the coil is wound in the absence of a magnetic field is discussed and it is shown that the induced e.m.f. $= -\frac{1}{2}id\mathrm{L}/dt$ and not $-id\mathrm{L}/dt$, where L is the inductance at a time t, giving for the potential energy of the coil the usual expression $\frac{1}{2}\mathrm{L}i^2$.

T. H.

343. *A Method for the Measurement of Inductance.* **W. H. Wilson.** (Electrician, 73. pp. 308–309, May 29, 1914.)—A description of three methods of measuring an inductance with the aid of a rotating interrupter. The inductance L of resistance r is connected in series with a resistance r_1, the interrupter I (Fig. 1) and a battery. On rotating the interrupter with the switch S open, a reading A_1 will be obtained on the moving-coil ammeter A; r_2 is a resistance for adjusting this current to a convenient value. The switch S is then closed, when the reading on the ammeter will fall to a value A_2, due to discharge of the quantity of electricity from the inductance on interruption of the magnetising current C. If the battery circuit is made and broken N times per sec. then $\mathrm{L} = (A_1 - A_2)\mathrm{R}/\mathrm{NC}$, where R is the total resistance of the circuit L, S, A, r_2, r_1; and $\mathrm{C} = v/(r + r_1)$. The time of each closing of

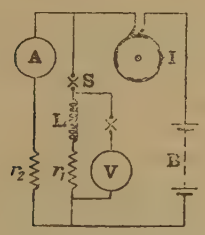


FIG. 1.

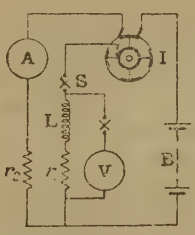


FIG. 2.

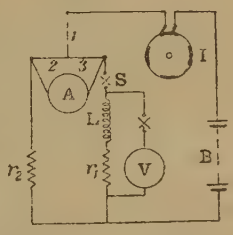


FIG. 3.

A_1, moving coil D.C. ammeter. B, battery. I, interrupter. S, switch. L, inductance. V, voltmeter. r_1 and r_2, non-inductive resistances.

the battery circuit should be sufficient to allow the current through L to attain its max. value; this condition will be practically obtained when the time of contact becomes numerically about 6 times the value of $\mathrm{L}/(r + r_1)$.

Much greater sensibility may be obtained by adopting the arrangement shown in Fig. 2. In this case by adjusting the brush connected to the ammeter so that it makes contact just before the other brush breaks contact with the battery, the initial current A_1 can be greatly cut down without increase of the resistance r_2. In Fig. 3, the numbers 1, 2 and 3 refer to non-inductive resistance shunts and the discharge current from the inductance may be read as a direct quantity and is therefore less susceptible to vibrations. If, in Figs. 1 and 2, the inductance L and resistance r_1 be replaced by a condenser, its capacity is equal to $(A_2 - A_1)10^6/\mathrm{NV}$ mfd.

The method has proved useful in the measurements of small inductances such as are used in connection with wireless telegraphy. W. C. S. P.

344. *Rotating Field Model.* **F. M. Denton.** (Electrician, 74. pp. 533–534, Jan. 22, 1915.)—The model is adapted for demonstrating the production

of a rotating field with the aid of a projection lantern. The stator is a plain ring with a 12-section winding connected to a mercury board. A watch-glass containing iron filings is supported, concave side upwards, on a glass pivot which lies on the axis of the stator; the watch-glass is just above the stator and can rotate freely. When low-frequency polyphase currents are supplied to the stator the watch-glass revolves and the filings, moving with it, maintain a constant configuration. The pivot is fixed to a glass base, so that the beam of light can pass up inside the stator, and an image of the filings be thrown on a screen. F. T. C.

345. *Electric High-temperature Vacuum Furnace.* **J. Wolf** and **E. Müller.** (Zeitschr. Elektrochem. 20. pp. 1–4, Jan. 1, 1914.)—The furnace proper consists of a horizontal carbon tube, 5 cm. external and 2 cm. internal diam., 30 cm. long, connected by threaded graphite nuts with water-cooled copper tubes which serve as leads; these tubes pass next to the carbon tube, through water-cooled cylinders. The cylinders are surrounded by a cylindrical water jacket, an air-tight packing being effected by the aid of rubber, vulcanised fibre, and asbestos; the jacket can be shifted so that the furnace tube is exposed. Between the carbon tube and the jacket are two concentric radiation screens of carbon, each consisting of two semi-cylinders, which are separated by quartz rings. Radiation in the longitudinal direction is prevented by graphite discs riding on the copper tubes. The carbon tube is cut, every 10 mm., by slits, 1 or 2 mm. in width, embracing $\frac{3}{4}$rds of the circumference. The substance is placed in a graphite boat, 10 cm. long, attached to a carbon rod which is supported in the furnace by quartz rings. Temperatures of 1722°, 2000°, 2500°, 2850°, are obtained with an expenditure of 3·64, 6·15, 12·16, 15·0 kw. (at 30 volts). These current consumptions are said to be much lower than those required by the Ruff furnace and by an Acheson graphite tube. The whole space within the jacket is evacuated. The furnace was designed especially for the study of metallic nitrides. **O. Ruff.** (Ibid. pp. 177–179, March 15, 1914.)—Ruff points out that a comparison between a vertical and a horizontal furnace of different constructions is not appropriate; the newer furnaces of the author are, moreover, much more economical than the old form to which Wolf and Müller refer, 2000° being obtained with a power expenditure of 7·6 kw., and 2700° with 18 kw. H. B.

ALTERNATING CURRENTS AND MAGNETISM.

346. *Theory of Magnetism.* **K. Honda.** (Tôhoku Univ., Sci. Reports, 3. pp. 171–188, June, 1914.)—A brief sketch of existing theories is given, and they are found insufficient to account for the observed facts. In the given theory, a modification of Langevin's, the author assumes that the moment of a molecular magnet is not constant, but a function of the temperature; also that the mutual action (magnetic or otherwise) of the molecular magnets has the effect of preventing the turning of the molecules caused by the external field. Further, the shape of the molecules is taken to be nearly spherical; in a paramagnetic substance the molecule has an elongated form, the transformation of a ferromagnetic substance into a paramagnetic at a high temperature being ascribed to elongation of the molecule with rise of temperature. In ferromagnetic substances, at low temperatures the effect of thermal impacts is very small in comparison with that of mutual action. With rise of temperature, the molecules gradually elongate and the effect of thermal impacts becomes more and more effective, till at last, with a

certain amount of deformation of the molecules, the substance becomes paramagnetic. Modifications are introduced into the theory in order to include paramagnetic substances above the critical temperature and diamagnetic substances. G. E. A.

347. *The Magnetic Coefficients of the Form and Material of a Body.* **V. Arkadieff.** (Russian Physico-Chem. Soc. J. 46. 1. pp. 22–42, 1914.)—In this article, which is largely of a mathematical character, the author designs in a simple manner to compute the magnetic susceptibility, the permeability, and the energy of substances. He considers, further, that the formulæ which he has evolved are not applicable alone to magnetic phenomena, but can be extended to others, such as the polarisation of dielectrics, to thermal and electric flux in bodies, immersed in conducting media, to the phenomena of diffusion and filtration of moisture through porous substances. The comparison of the usual coefficients of material with the coefficients of form introduced by the author is claimed to possess more than an ordinary significance. The following inferences are deduced: (1) The relation existing between the permeability of form and substance for a triaxial ellipsoid. (2) The means of calculation of the magnetic coefficients of various geometrical bodies. (3) The coefficients of cylindrical bundles as related to coefficients of cylinders. (4) The most advantageous form of a body for accumulating magnetic energy, and thus the most profitable construction of solenoids with iron. Under the heading for permeability of form for certain geometrical forms the author discusses the ellipsoid of revolution. In the following table the symbol Λ represents the ratio of the axes, *i.e.* a/b and a/c, and in the case of the cylinder b/c. H is the demagnetising factor and M the permeability of form.

Form.	Λ.	H_a.	$H_b = H_c$.	M_a.	$M_b = M_c$.
Infinitely thin disc	0	$4\pi = 12{\cdot}56$	0	1	∞
Spheroid.....	0·01	12·30	0·0967	1·02	130
,, ...	0·1	10·82	0·865	1·16	14·5
,, ...	0·5	6·60	2·97	1·90	4·19
Sphere	1	$4\pi/3 = 4{\cdot}19$	$4\pi/3 = 4{\cdot}19$	3	3
Ovoid	2	2·18	5·21	5·78	2·41
,, ...	5	0·702	5·86	17·9	2·14
,, ...	10	0·255	6·16	49·5	2·04
,, ...	15	0·135	6·22	93	2·02
,, ...	20	0·0848	6·25	148	2·01
,, ...	40	0·0266	6·27	472	2·00
,, ...	100	0·00537	6·28	2,340	2·00
,, ...	500	0·000295	6·28	42,600	2·00
Infinitely long cylinder	∞	0	2π	∞	2

E. O. W.

348. *Longitudinal and Transverse Magnetostrictive Effects in the same Specimens of Steel and Nickel.* **S. R. Williams.** (Phys. Rev. 4. pp. 498–506, Dec., 1914.)—Measurements of changes in dimensions were made upon two specimens of steel and two of nickel, the transverse effect in Ni being measured with considerable difficulty owing to heat effects. In Bidwell's experiments the direction of the magnetic field employed was fixed, and the variations of two dimensions at right angles to one another were measured. For some reasons it seems preferable to use successively two fields at right

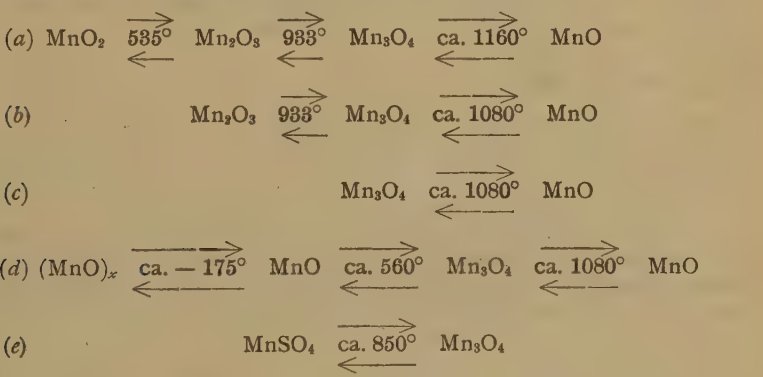
angles and measure the change in length in one direction. This was the method adopted in the experiments now described. The specimens were in the form of tubes, and the longitudinal fields were obtained by surrounding the specimen with a long solenoid, corrections being made for the end effects of the solenoid and for the demagnetising effect of the cylinder itself. The transverse fields were obtained by winding on the specimen a toroidal ring, room being left for free expansion of the material. The change in length of the cylinder was measured by means of the displacement of interference bands produced by the light reflected from two glass plates arranged close together and carried at the ends of two rods, the other ends of which were fastened to the ends of the specimen. This device could be used without disturbing the system both in the longitudinal and transverse effects. The change in length was measured as the field was increased from zero upward, with several makes and breaks of the circuit for each field strength measured. Demagnetisation by reversals occurred after each series of readings. The results obtained are shown graphically; they exhibit a qualitative reversal of the two effects as the planetesimal hypothesis would indicate. An exact quantitative reversal is not to be expected for several reasons: (1) non-homogeneity of the specimens, (ii) non-uniformity of the transverse field, and (iii) the elementary magnets affected by the longitudinal field will be different from those influenced by the transverse field. It was found that long thin specimens are much better to work with than short ones. [See also Abs. 339 (1914).] A. W.

349. *Magnetic Study of Compounds of Water and of Aqueous Solutions.* **F. W. Gray** and **W. M. Birse.** (Chem. Soc. J., Trans. 105. pp. 2707–2716, Nov., 1914.)—The magnetic measurements here described were made with the object of throwing light on the state of combination of water in compounds of different types and to determine the magnetic properties of water in (1) aqueous salt solutions, (2) hydrated crystals such as those of copper sulphate, and (3) organic acids, such as benzoic and phthalic acids, which may be regarded as compounds of their anhydrides with water. In all these classes instances were found in which the law of additivity, in the molecular sense, is obeyed. Thus aqueous solutions of potassium ferricyanide obey this law throughout the whole range of concentration, and yield a more trustworthy value for the susceptibility of potassium ferricyanide than that obtained from the solid. In the case of copper sulphate, if it is assumed that the susceptibility of the water is not affected appreciably by the union, it is found that the paramagnetic susceptibility of the anhydrous copper sulphate molecule is increased by about 11·5 % when it unites with one molecule of water. Further addition of water molecules to form the higher hydrate has no marked influence on the susceptibility. With organic acids it is found that additivity, in the molecular sense, holds for benzoic, phthalic, maleic, and fumaric acids, but not for succinic and camphoric acids; with the two latter acids, formation from the anhydrides is accompanied by marked change in the configuration of the atoms and their electrons.

Aqueous solutions of potassium ferricyanide correspond very closely with the equation, $x/10{\cdot}07 - y/0{\cdot}72 = 1$, where x is the weight of the ferricyanide in 100 gm. of solution and $y \times 10^{-6}$ denotes the susceptibility of this solution. It is not usual for an aqueous solution to exhibit such approximate additivity, and many of the older determinations are, indeed, valueless, being calculated from determinations of salt solutions of single concentrations on the basis of additivity.

Substitution of 100 for x in the above equation gives the value $+6{\cdot}43 \times 10^{-6}$ for the susceptibility of potassium ferricyanide, this corresponding with 10·97, or very nearly 11, magnetons per molecule ; direct measurement of the solid salt gives $+ 6{\cdot}77 \pm 0{\cdot}16 \times 10^{-6}$, *i.e.* 11·26 magnetons per mol., while Weiss [Abs. 677 (1911)] gave 10·41. In explanation of the magnetic difference between monohydrated and pentahydrated copper sulphate, it is suggested that one water molecule is in the vicinity of each oxygen atom and one in the vicinity of the copper atom, and that only the last water molecule causes deviation from the additivity of the magnetic properties. Various observations are quoted in support of this hypothesis. T. H. P.

350. *Magnetic Changes in Manganese Compounds at High Temperatures.* **K. Honda** and **T. Soné.** (Tôhoku Univ., Sci. Reports, 3. pp. 139–152, April, 1914.)—The compounds were examined thermomagnetically over a range of temperature from —190 to 1200° C., partly to find what changes these compounds undergo at high temperatures, and partly to test Onnes and Perrier's modification of Curie's law over as wide a range of temperature as possible. The field employed at high temperatures was 9260 gauss, and with low temperatures 2012 gauss. The constitutional changes as deduced from the thermomagnetic observations are given as follows :—


(a) MnO2 535° Mn2O3 933° Mn3O4 ca. 1160° MnO
(b) Mn2O3 933° Mn3O4 ca. 1080° MnO
(c) Mn3O4 ca. 1080° MnO
(d) (MnO)x ca. — 175° MnO ca. 560° Mn3O4 ca. 1080° MnO
(e) MnSO4 ca. 850° Mn3O4

The Curie or Onnes-Perrier law is not strictly followed by the five compounds over this wide interval of temperature. [See also Abs. 1895, 1896 (1914).] G. E. A.

351. *Susceptibility of Rocks.* **H. Takagi** and **T. Ishiwara.** (Tôhoku Univ., Sci. Reports, 3. pp. 127-138, April, 1914.)—In continuation of a study of soils and sands [Abs. 1898 (1914)] the specific susceptibility was measured by the Curie method. The specimens were investigated in the solid form, and susceptibilities are given for about fifty different kinds of rock classified as igneous, aqueous and Eolian, metamorphic, and minerals. Of these the igneous rocks are generally very strongly paramagnetic, and it is verified that they seem to owe their magnetisability principally to the magnetic constituent magnetite. Several rocks and minerals, such as limestone, fluorite, microcline, and quartzite, are diamagnetic, and schistose rocks show different susceptibilities in different directions. A change of susceptibility with field intensity was also noted, and curves are given showing this change. [See also Abs. 1100 (1909).] G. E. A.

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352. *Molecular Magnitude of Metals in the Solid Phase.* **M. Padoa** and **F. Bovini.** (Soc. Chim. Ital., Gazz. 44. ii. pp. 528–534, 1914.)—When a solid solution of concentration C_s separates from a dilute solution of concentration C_l, and the ratio $C_s : C_l$ is constant for solutions of different concentrations, it may be asserted that the solute has the same molecular magnitude in the solid as in the dissolved state. The authors have investigated three different alloys of Sn, Cd, and Bi. The first two metals form a eutectic and limited solid solutions, which are transformed, at a temperature just above 100°, into the compound, Sn_4Cd; Sn and Bi, and also Cd and Bi, give eutectics, but no solid solutions. The ternary alloys examined, which solidify at about 200°, present no further complications. In the three cases, the ratio of the concentration of the cadmium with respect to the tin in the crystals to that in the liquid has the values 0·986, 0·985, and 0·957 respectively. The solid solutions separating from different liquid solutions of Cd in Sn have, therefore, approximately the same concentration, the coefficient of distribution being sensibly constant. The conclusion is drawn that cadmium has the same molecular magnitude in solid solution in tin as in liquid solution, that is, it is monatomic.

These results tend to confirm Stoffel's data concerning these ternary alloys [Abs. 908 (1907)]. T. H. P.

353. *Structural Changes in Industrial Brasses.* **D. Meneghini.** (Ann. Chim. Applicata, 2. pp. 154–158, 1914.)—The brass parts of incandescent gas burners were found to become very brittle, and, in some cases, to fracture spontaneously. Analysis revealed no change in the composition of the brass, which contained 64·5 % of Cu, 35·0 % of Zn, 0·3–0·4 % of Pb, and traces of Fe. Micrographical examination showed that the majority of the specimens consisted solely of the homogeneous α-solution, although in a few instances traces of β- and γ-solutions were observed; no sign of the polyhedral structure noticed in analagous cases was detected. After the fragments of brass were reheated at 700°, they were found to have undergone a marked diminution in the superficial hardness, such diminution varying from point to point of one and the same fragment. These effects are probably the result of, first, the mechanical treatment to which the metal is subjected during the shaping of the parts, and, secondly, electrolytic action due to the SO_2 formed during the combustion of the gas and to moisture. In order to avoid the so-called "Forcierkrankheit," that is, the formation of internal tensions caused by the heating of brass which has been worked below its final temperature of solidification, the metal should contain at least 70 % of copper. Even with such alloys, consisting entirely of the α-solution, trouble may occur unless, after they have attained their final shape, they are rendered stable by suitable reheating. T. H. P.

354. *Disintegration End-products of the Radio-active Series.* **K. Fajans.** (Zeitschr. Elektrochem. 20 pp. 449–452, 1914.)—According to the author the end-products of the three disintegration-series uranium-radium, thorium, and actinium, should all be members of the lead pleiades (isotopic elements of Soddy), and there should be several leads, atomic weights ranging from 206 to 208·4, whilst ordinary lead is 207·1. From lead salts,

obtained from two uranium minerals (carnotite from Colorado and pitchblende from Joachimstal) both free from thorium, Lembert [see Abs. 1751 (1914)] deduced the atomic weights of uranium-lead 206·59 and 206·57; this lead probably contained some actinium-lead in addition to radium-lead. Atomic weight determinations with thorium salts are much more difficult since all thorium ores seem to contain some uranium. H. B.

355. *Forms of Phosphorus.* I. *Changes of Phosphorus Vapour caused by Glow Dischage.* **V. Kohlschütter** and **A. Frumkin.** (Zeitschr. Elektrochem. 20. pp. 110–123, 1914.)—Sticks of white phosphorus, up to 1 gm. in weight, are introduced into the discharge bulb, which is before and afterwards, evacuated and swept with CO_2 and H, and finally charged with helium, hydrogen, argon or nitrogen at 0·5 mm. Hg; the Al electrodes are replaced after each experiment. Distilled *in vacuo* in the bulb the phosphorus condenses in crystals; when the current is turned on, no heating is required. Continuous and alternating currents, generally kept at 3×10^{-4} amp. had practically the same effect; the pressure has to be raised from 500 volts to thousands of volts because the electrodes, particularly the kathode, become covered with converted phosphorus. The bulb is afterwards filled with water to remove the deposit. The appearance of the deposit, its dispersity, density, adhesion to the wall, colour (orange, red, violet, brown to black), etc. change with the nature of the residual gas in the tube. The general effect of the presence of a gas is to loosen the deposit; argon does this more strongly than helium. Hydrogen and nitrogen enter into combination with the phosphorus; these compounds appear homogeneous with the further layers of changed phosphorus, except at higher gas pressures when mixtures of different substances can be distinguished under the microscope. Heated, the deposit changes into red phosphorus, and the formerly observed differences in appearance vanish. The first product seems to be Hittorf's finely divided phosphorus, which is deposited from suddenly cooled, superheated phosphorus vapour; when heated this product sinters and changes into ordinary red phosphorus, which looks like the anhydrous gel of tin oxide. The author speaks of forms, and not of modifications, because the appearance mainly depends upon the conditions at the moment of condensation or formation. H. B.

356. *Hydrogen Peroxide of* 100 % *by the Silent Discharge.* **P. M. Wolf.** (Zeitschr. Elektrochem. 20. pp. 204–219, 1914.)—Reviewing the literature on the preparation of hydrogen peroxide, the author concludes that the combustion of hydrogen in oxygen yields H_2O_2, which at the high temperature of the reaction is at once decomposed into H_2O and O. It should hence be possible to synthetise H_2O_2 by effecting the combination at low temperatures, that is to say, by preventing an explosive combination; this can be done in three ways: by working at reduced gas pressure; by using an excess of either H or O; or by mixing the electrolytic gas with an indifferent gas, CO_2. The three ways are tried, the silent discharge being utilised as a catalyst. The apparatus are fully described. Electrolytic gas does not explode when the pressure is kept below 146 mm. Hg; the stream of electrolytic gas is sent through a U-tube through which the discharge passes, and the gas is then condensed in liquid air; the liquid is taken up by water. During the latter process a mist (probably vapours of H_2O_2, often noticed by previous experimenters) was always observed; when the flushing with water was carried out with the greatest care, very little mist appeared, and the yield of H_2O_2 rose to 6 times its value,

but it never exceeded 17 %. By the second method mixtures by volume of 96·5 H and 3·5 O proved most effective; the best current-intensity in the primary of the induction apparatus was 4·6 amps.; the gas feed 0·4 litre per hours, the temperature — 80°; the gas mixture should contain some water-vapour. Under these conditions the yield of a hydrogen peroxide of 99·9 % amounted to the same figure, 99·9 %. When the Berthelot tube was cooled with liquid air, the ozone also formed was likewise condensed at — 110°; when the cooling was effected at — 80°, the ozone and hydrogen reacted with one another and increased the yield of H_2O_2. The third method, dilution of the electrolytic gas with CO_2, did not give more than 4 % of the theoretical yield of peroxide. Experiments were finally made by passing a stream of non-explosive electrolytic gas over thin wire spirals of Cu, Ni, Fe, Pt, Pd, etc., electrically heated; the glow increased or started again; the yield of H_2O_2 was always poor, however; some ozone was also formed, especially with Al wire. H. B.

357. *High-temperature Investigations.* III. *Tungsten and Carbon.* **O. Ruff** and **R. Wunsch.** (Zeitschr. Anorg. Chem. 85. pp. 292–328, Feb. 10, 1914. Rev. de Mét. 11. E. pp. 531–533, Aug., 1914.)—The objects of the investigation were to find substances for standard melting-points above 2000°, and to study the influence of carbon on tungsten and the systematics of the carbides. Tungsten and its carbides are not suitable for temperature standardisation. Tungsten, even when solid, absorbs carbon from the electric furnace atmosphere, especially when heated slowly and so long as it contains little carbon; the surface layer is thereby converted into a carbide and the melting-point rises; the layer may contain more C than is soluble in the metal; in a coal-gas atmosphere 7·68 % of C may be taken up by the liquid metal under formation of the monocarbide. The preparation of definite carbides is for these reasons very difficult. Rods are prepared by mixing the metal and carbon under addition of some ammonia, drying the rods and heating them directly by the current in a hydrogen atmosphere; the same furnace serves subsequently for fusing the crude carbide in the arc, the electrodes being rods of this carbide and of tungsten; the heating must be rapid. The first carbide formed is probably W_3C, which melts above 2700°, without decomposition. It is soluble in the solid metal and appears as a separate constituent already when 0·12 % C is present; tungsten filaments should, therefore, not contain so much carbon. The determination of the amount of carbide and of its influence upon the mechanical properties of the metal is very difficult; the rise of the melting-point produced by 0·1 % C is about 35°. When the liquid containing much carbon is rapidly cooled from 2800°, the carbide WC is formed; it decomposes under slow cooling. The monocarbide cannot be fused without decomposition; it exists already in alloys containing 2·5 % C; it seems to be metastable; at about 2685° the equilibrium concentration is 3·8 % C; at higher temperatures the fused mass absorbs C again, up to 6·12 % (in the arc), which would correspond to the monocarbide. The carbide W_2C, which Moissan claimed to have obtained, could not be isolated; the micrographic study suggests its existence. There are three eutectics, containing 1·4, 2·7, 3·5 % and melting at 2609°, 2660° and 2580° (Wanner pyrometer). By treatment with acids (HF, HNO_3) and aceteylene tetrabromide, only the monocarbide can be isolated, not the others. The system W–C resembles that of iron, nickel, and manganese. They all give a carbide M_3C, which is the more stable carbide at lower temperatures, if several carbides be then co-existent. H. B.

358. *Solvents (for Electrolytes) of Small Dielectric Constants.* **A. Sachanov and J. Prscheborowsky.** (Zeitschr. Elektrochem. 20. pp. 39–41, 1914.)—Sachanov having shown that the molecular conductivity decreases when solutions in solvents of small dielectric constant are diluted, further experiments are made with chloroform (D.C. 47), bromal (7·5), benzylamine (5·2), orthotoluidine (6·0), α-bromobutyric acid (7·2) and isobutyric acid (2·6), organic and inorganic salts being dissolved in these substances and the solutions examined at 25°. The law stated is confirmed. The specific conductivity of all these solvents themselves is very small, below 10^{-7}. Tetramethyl ammonium iodide is dissociated to a considerable extent in orthotoluidine, and also more strongly still in aniline. The decrease of the conductivity λ (in mho) of the solutions is given by : $\lambda\, v^n . H/h = \text{const.}$, where v is the dilution (in litres per mol.), n a constant, and H and h are the viscosities of the solution and the solvent; for higher dilution : $\lambda v^n = \text{const.}$, in practical agreement with Kraus and Bray. H. B.

359. *Transformations of Steels.* **H. De Nolly** and **L. Veyret.** (Iron and Steel Inst., J. 90. pp. 165–179, 1914. Engineering, 98. pp. 631–632, Nov. 20, 1914.)—The carbide theory of the variation in the properties of steels at transformation-points only indifferently explains certain facts connected with the phenomena of dilatation. These facts, however, are readily explained by the allotropic theory on the assumption that the transformation α- to γ-iron is accompanied by shrinkage, whereas the dissociation and solution of the carbide is accompanied by dilatation. According to the carbide theory there should be little change in volume at the transformation-point in low-carbon steels, since there is so little carbide present, whereas according to the allotropic theory there should be a considerable shrinkage owing to the fact that the α–γ change is at a maximum. This is actually what is found by experiment: shrinkage is much more marked in dead-soft steels than in hard steels. The curves for eutectoid and hyper-eutectoid steels show that the solution and precipitation of the carbide lag behind the allotropic transformation of the iron during both heating and cooling. On rapid cooling, or, by carrying out the transformation at an artificially lowered temperature as in the case of special steels, the precipitation of the carbide may be obviated. The γ-iron will be transformed into α-iron, but the carbide remains dissolved in a state of supersaturation in the α-iron, giving rise to martensite. This accounts for the lower density of hardened over annealed steel owing to the suppression of the shrinkage occasioned by the carbide change. Again, the shrinkage does not occur in self-hardening steels. Further, the authors have observed a shrinkage on tempering martensitic steels. This shrinkage occurs at 200–400° C. on heating hardened carbon steels and at 700 to 750° C. in high-speed steels. Austenite is considered as a solid solution of iron, carbide of iron, and carbon, in a state of equilibrium analogous to the hydrogen-iodine vapour system. The relative proportions of the various constituents corresponding with equilibrium will vary with the temperature and the composition of the steel and according to the respective solubilities of the carbon and the carbide in the γ-iron it will be possible to obtain either carbide or graphite on cooling. In ordinary steels the carbide first attains its saturation point when cementite separates out, and a partial combination of the iron and carbon takes place to restore the disturbed equilibrium in the solution. In high-silicon steels, however, the solubility of carbon is reduced so that, on cooling, it is the graphite

which first attains its saturation-point, with the result that graphite separates out and a partial dissociation of the carbide takes place in order to restore equilibrium in the solution. F. C. A. H. L.

360. *Surface Decarbonisation of Tool Steel.* **J. V. Emmons.** (Am. Inst. Mining Eng., Bull. pp. 2233–2248, Sept., 1914.)—Contains the results of experimental work on the effect of various treatments in eliminating carbon from the surface of tool steel. Pieces of tool steel were heated in various gases and the results noted. After heating in hydrogen to 1800° F. for 3 hours and to 2130° F. for 6 hours, the pieces had a dull grey crystalline appearance, but no trace of decarburisation was found. Similar pieces of tool steel, after heating in carbon dioxide to temperatures at and above 1400° F. for 3 hours showed distinct signs of decarburisation, the depth being 0·007 in. at 1400° F. and increasing to 0·072 in. at 2000° F. On annealing in air and in oxygen results similar to those in CO_2 were obtained, but in the case of CO no decarburisation was found. On heating in steam at 1700° F. distinct decarburisation was found to have taken place. C. O. B.

361. *Metallography of German Silver.* **F. C. Thompson.** (Chem. Soc., J. 105. pp. 2342–2349, Oct., 1914.)—Oxygen present in German silver is probably in combination with zinc as zinc oxide. In polished specimens without etching this oxide is seen as very fine black inclusions at high magnifications (1000 diams.). The addition of deoxidants, such as Mn and Al, to alloys which are afterwards rolled into sheets and annealed, causes a refining of the grain-size, the mean area of the crystals in treated sheets being 0·0005 cm.^{2}, whilst the mean area of the crystals in sheets made from similar alloy to which no deoxidants have been added was 0·3 cm.^{2}. Over-annealing of German silver causes brittleness and a structure similar to that of cast material. Lead is insoluble in German silver and separates as globules which become elongated into threads on rolling. Tin likewise separates from German silver, but probably as a copper-tin compound. Certain analogies between German silver and steel are pointed out, the most obvious of which are: (1) The annealing temperature-range, 900° to 700°, is the same, being less as the Ni or the carbon increases. (2) Overheating causes a return of the cast structure with an accompanying loss of ductility. (3) The mechanical properties of German silver are not dissimilar from those of a normal mild-steel. (4) In each case increased Ni-content is accompanied by a diminution in the size of grain. (5) The mechanism of the recrystallisation after cold work appears to be the same in each case. (6) The original cast structure of each is similar. C. O. B.

362. *Influence of Coalescence on the Mechanical Properties of Steel and Alloys.* **A. M. Portevin** and **V. Bernard.** (Iron and Steel Inst., J. 90. pp. 204–210, 1914.)—Coalescence is the result of capillary forces acting in a heterogeneous solid system and tends to establish structural equilibrium. It is a phenomenon which is general in all alloys containing a eutectoid. Experiments carried out on two bronzes, one consisting of α and the δ complex and the other consisting wholly of the δ complex, showed that coalescence could be effected by causing the temperature to oscillate just above and below the eutectoid point. Under such treatment the hardness of the first-named alloy was diminished, while that of the second alloy remained unchanged. In steels, two phenomena are met with: (1) the liquation of the proeutectoid constituent, and (2) coalescence. The first is effected by comparatively short annealing at 800° C., while the

second can only be attained by prolonged annealing at 700° C. Coalescence is accompanied by a reduction in the breaking stress, elastic limit, resilience, and the hardness and by an increase in the contraction and elongation. Experiments made with a view to determining whether the properties of the steel after heat-treatment were independent of the structure of the steel previous to such treatment showed that with a 10 minutes' heating at 850° C. prior to quenching the resulting mechanical properties differ according to the pre-existing condition of the steel. These differences disappear after heating the steel for 30 mins. prior to quenching. The results are somewhat at variance with those obtained by Hanemann and Morawe [Abs. 2030 (1914)] and point to the different results obtained when the conditions of annealing are varied being due to the coalescence and liquation of the structural elements. F. C. A. H. L.

363. *Influence of Phosphorus on the Quality of Mild Steel.* **E. d'Amico.** (Ferrum, 10. pp. 289–304, 1913. Rev. de Mét. 11. E. pp. 566-570, Aug., 1914.)—The author reviews the results of earlier workers in this field and attributes the variations to differences in the products and methods used in the investigations. A series of steels containing 0·11 to 0·16 % C, 0·40 to 0·55 % Mn, 0·05 to 0·08 % S, 0·17 to 0·25 % Si, and 0·012 to 1·25 % P were prepared and submitted to various mechanical, electrical and magnetic tests in the as-rolled, annealed, and quenched from 900° C conditions. The Brinell hardness is increased by about 12 units for each 0·1 % of P added, while the elastic limit is increased by about 2·7 kg./mm.^{2} for each 0·1 %. The ultimate stress reaches a maximum at about 0·6 to 0·7 %. In the quenched state there is a very rapid fall in the strength between 0·7 and 0·85 % P. The resilience (Charpy notched bars) decreases continually as the phosphorus rises, and above 0·25 % the value becomes practically zero. The electrical resistance is practically proportional to the content of phosphorus, and is increased by about 0·11 ohm (referred to a wire of 1 mm.^{2} and 1 m. length) for each 1 % added. The coercive force, remanance, and hysteresis losses are decreased, while the permeability is increased, by the addition of phosphorus. While quenching has little effect on the resistance the magnetic properties are considerably affected, the hysteresis being increased and the permeability lowered. F. C. A. H. L.

364. *Dilatation of Bars Heated Electrically.* **Thanoin.** (Bull. Techn. des Écoles d'Arts et Métiers, pp. 666–685, 1913. Rev. de Mét. 11. E. pp. 570–571, Aug., 1914.)—The phenomenon of the bending of metallic bars when heated electrically to temperatures in the neighbourhood of 1000° C. is discussed. The curvature increases with the number of times of heating, and ultimately persists partially after cooling. F. C. A. H. L.

365. *Contribution to the Study of Nickel Steel.* **P. Chevenard.** (Rev. de Mét. 11. pp. 841–862, Aug., 1914.)—The author describes the apparatus and the methods used in carrying out the work already described in Abs. 1845 (1914) and discusses the results at greater length. F. C. A. H. L.

366. *The System Iron-Copper.* **R. Ruer** and **C. Fick.** (Ferrum, 11. pp. 39–51, Nov. 8, 1913.)—Recent investigators partly contradicting one another and Sahmen (1908), the authors resume the investigations. The two metals, about 25 gm. of each, were fused in a porcelain tube in a current of nitrogen. Copper retains only 1 or 2 % Fe in solid solution, whilst iron dissolves up to 20 % Cu at 1440°, much less at lower temperatures. There are

thus three series of solid solutions ; in the middle, horizontal portion of the freezing-point curve separation of the two layers takes place only when the iron contains carbon, 0·02 % C ; this influence of carbon may merely be a deoxidising effect. The magnetic change-point was lowered to 760° by the addition of copper. The electric resistance was determined on forged rods of the alloy ; iron containing more than 6 % Cu would not forge. The resistivity of iron rises first when up to 1 % Cu is added, and decreases afterwards, the resistance being at 100, 99·5, 99, 98·5 % Fe : 11·84, 13·70, 16·04, 14 microhms-cm. H. B.

367. *The System Iron-Cobalt.* **R. Ruer** and **K. Kaneko.** (Ferrum, 11. pp. 33–39, Nov. 8, 1913.)—The iron was of 99·8 % with 0·08 % C ; the cobalt contained 0·035 % C and about 1 % of oxide ; the oxide could be removed by melting the metal in a china crucible. The alloys were prepared by fusing the metals together. The system had been studied by Guertler and Tammann in 1905. The transformation point of γ into δ iron, 1420° for pure iron, is raised by the addition of Co, to 1490 by 15 % Co, to 1491 by 20 % Co. The freezing-point curve descends from 1524° (pure iron) to 1496° (80 % Fe), and slowly to a minimum at 1475° (35 % Fe) ; the curve has two branches corresponding to the solidification of two series of solid solutions, and intersecting at 1493° and 15 % Co. The magnetic changes were observed after Lewkonja ; for the range 85 to 30 % Fe the temperatures of heat-changes and of magnetic changes coincide, the maximum being at 980° and 57 % Fe, probably corresponding to Fe_4Co_3. There was no microscopical evidence of the transformation. H. B.

368. *Cerium-Silicon and Cerium-Bismuth Alloys.* **R. Vogel.** (Zeitschr. Anorg. Chem. 8. pp. 323–339, Dec. 19, 1913. Rev. de Mét. 11. E. pp. 528–530, Aug., 1914.)—As with tin and lead, cerium combines under liberation of considerable heat also with silicon, and cannot therefore chemically be grouped with these elements. Ce and Si combine only at high temperature, about 1400°, but then with great violence ; cerium carbides are formed in carbon vessels ; other vessels are attacked, and the silicon is oxidised ; for these reasons compounds with from 0 to 30 % Si could not be prepared. In the presence of cerium carbides the alloys rapidly disintegrate. The freezing-point curve has two branches which intersect at 1240°, the eutectic containing 47 % Si ; the minimum percentage of Si seems to be 17, and the compound CeSi therefore probable. This compound forms yellowish rounded crystallites which are very hard and brittle, can be kept for months exposed to the air, and are not attacked by concentrated acids at ordinary temperature. The reaction between Ce and Bi is still more violent ; porcelain tubes are attacked ; carbon tubes may be used, as the carbides do not cause serious trouble in this case. The study of freezing-point curves is very difficult, the micrographic examination likewise, because the alloys, especially when poor in Bi, oxidise rapidly under liberation of heat ; the richer Bi alloys crumble to powder. Four compounds are formed : $BiCe_3$, Be_3Ce_4, BiCe, Bi_2Ce. The melting-point of Bi_3Ce_4 is 1630°, extraordinarily high, 1368° above that of Bi ; this difference surpasses even those observed in the cases of Ce_2Sn and $CeAl_2$. $BiCe_3$ is formed at 1400°, BiCe at 1525°, and $BiCe_2$ at 828°. All the alloys are attacked by water (more readily than cerium), and all trace of moisture must be removed during the micrographic examination. In only one of these four compounds Ce appears trivalent ; and cerium seems to be similarly related to Bi, Al, Si, Sn, Pb. H. B.

369. *E.M.F.'s in Alcohol.* IV. *Combinations of the Hydrogen and Calomel Electrodes.* **R. Furness, R. T. Hardman,** and **E. Newbery.** (Chem. Soc. J., Trans. 105. pp. 2302–2309, Oct., 1914.)—The earlier investigations have been continued in the hope that it might be possible to compare by electrometric methods the thermodynamic potentials of highly dilute hydrogen chloride in water and alcohol respectively. The authors have measured the potential differences required to determine (*a*) the behaviour of the calomel electrode in alcoholic solutions of mineral chlorides; (*b*) the influence of metallic chlorides on the potential of the hydrogen electrode in alcohol; and (*c*) the p.d.'s between electrodes reversible to chloridion and hydrion respectively in alcoholic solution. They have also submitted their results to a careful theoretical analysis.

Certain discrepancies between calculated and measured p.d.'s, which could not be accounted for by any hypothesis of experimental error, have led to the important conclusion that the calomel electrode does not give trustworthy results in acid-alcoholic solutions, although it behaves satisfactorily in dilute alcoholic solutions of sodium chloride. T. M. L.

370. *E.M.F.'s in Alcohol.* V. *The Dropping Electrode in Alcoholic Solutions.* **E. Newbery.** (Chem. Soc. J., Trans. 105. pp. 2553–2562, Oct., 1914.) The following figures are given by the dropping electrode as the absolute potentials of the calomel electrode in the solutions stated, at 25° :

	(*a*)	(*b*)
In saturated sodium chloride (aqueous)	0·595 volt.	
„ „ „ „ (alcoholic).....	0·329 „	0·331 volt.
„ normal „ „ (aqueous)	0·552 „	
„ decinormal „ „ „	0·535 „	0·579 „
„ „ potassium chloride „	0·572 „	0·582 „

The figures in column (*a*) were obtained with the aid of an alkaline sulphate, those in (*b*) with an alkaline cyanide. Of these figures, the value given in (*b*) for N/10-potassium chloride solution at 25°, and for N/10-sodium chloride solution may be taken as approximately correct. The remaining figures cannot represent true absolute potentials, since the potential of the calomel electrode according to these results is greatest in the saturated solution, and least in the most dilute; this is directly contrary to theory, and will be shown later to be contrary to fact. T. M. L.

371. *Effect of Magnetisation of the Electrodes on the E.M.F.* **G. J. Elias.** (K. Akad. Amsterdam, Proc. 17. pp. 745–759, Dec. 24, 1914.)—The question of the influence of magnetisation of the electrodes on the e.m.f. in a circuit in which there are electrolytes has often been investigated, but no definite answer has been attained. The only case capable of exact thermodynamic treatment is that in which the electrolyte is a dilute solution of the metal of the electrodes, the latter being similar, and for this case the author deduces, by a lengthy process, the value of the p.d. Experiments made with electrodes of electrolytic iron immersed in ferrous sulphate solution show that excitation of the magnetic field is always accompanied by a current in the sense required by theory, but the values of the p.d. found are 10 to 20 times as great as the formula obtained would indicate. At first the p.d. was about proportional to the second power of the strength of field, and attained a value of $6{\cdot}3 \times 10^{-4}$ volt at about 16,000 gauss, this value then remaining unchanged on further strengthening of the

field. If the solutions used were neutral, the effect remained moderately constant after excitation of the field, but with solutions containing a very small proportion of free acid, diminution and reversal of the effect soon occurred, a value being reached about 10 times as great as that of the initial effect following excitation of the field. Further, the resistance of the solution increases markedly with the duration of its stay in the field. With pure Ni electrodes in 5% nickel sulphate solution, no certain effect could be observed while the solution remained neutral, owing to the rapid and enormous increase in the resistance of the solution, but there is probably an effect which is in the theoretical direction and about one-fifth as large as with iron and consequently more nearly in harmony with the theoretical magnitude. With nickel sulphate solutions containing sulphuric acid no effect was observed other than that found with neutral solutions, *i.e.* no reversal occurs.

T. H. P.

372. *Application of the Theory of Allotropy to Electromotive Equilibria.* III. **A. Smits** and **A. H. W. Aten.** (K. Akad. Amsterdam, Proc. 17. pp. 680–694, Nov. 27, 1914.)—The authors first enumerate and briefly discuss the various theories of the cause of the passivity of metals, and then describe experiments made to decide whether the boundary surface between metal and electrolyte or, as the theory of allotropy has rendered probable, the metal surface itself is the seat of the polarisation and passivity [Abs. 1024, 1762 (1914)]. The electrode of the metal to be investigated, fastened to a Pt thread, was etched with acid, quickly rinsed with water, immersed and rotated in N/10 salt solution, and its potential with respect to a N/10 mercurous chloride electrode measured as rapidly as possible. With silver, copper, and lead, which quickly assume internal equilibrium, the potential is not changed by etching, but with Co, Ni, Cr, and Fe, potential-rises of 0·107 to 0·109, 0–0·1, 0·6–1·0 and about 1·0 volt respectively, according to the etching agent used, were found. Similar measurements with iron, rendered passive by anodic polarisation or by etching with concentrated nitric acid, and immersed in N/10 ferrous sulphate solution, show that the p.d. with respect to the decinormal mercurous chloride electrode at first decreases fairly rapidly, then remains constant for a time and subsequently falls rapidly again, the two passive states being identical. Increased effects were obtained when the above metals were attacked while immersed in their salt solutions and the potentials measured at the same time. In the case of Ni, gradual addition of bromine water raises the potential by amounts varying to a maximum of about 0·65 volt, a considerable decrease to a constant value afterwards occurring; this value remains practically unchanged when the concentration of the bromine reaches the saturation point. These results are shown to be due to the fact that the disturbance of the internal equilibrium by the action of the bromine is influenced catalytically by bromine ions formed when the metal is etched. Of the other metals examined, chromium shows behaviour most nearly akin to that of Ni. With iron, the potential of a rotating electrode immersed in N/10 ferric chloride is not affected by addition of either bromine to the point of saturation or N-potassium bromide solution. This result is due to the fact that iron is attacked both by ferric chloride solution and by bromine, the disturbance effected being smaller in the latter case than in the former. Substitution of the bromine by chlorine, which acts more strongly on iron, is accompanied by a marked rise in the iron potential.

The above phenomena may be accounted for on the assumption that iron contains ions of different valencies.

T. H. P.

373. *Electrolytic Dissociation of Acetylene and its Metallic Derivatives.* **M. Skossarewsky.** (Comptes Rendus, 159. pp. 769–771, Dec. 7, 1914.)—When acetylene is dissolved in liquid ammonia and its molecular conductivity measured at —45 and 0°, the dissociation of the acetylene is found to increase with the dilution of the solution ; the thermal coefficient of the conductivity is about 2% per degree and nearly independent of the concentration. The molecular conductivity of the sodium acetylid C_2HNa, at medium concentration in liquid ammonia, is of the order of that of sodium acetate in aqueous solution. Two accumulator cells are required for the electrolysis, which yields metallic sodium at the kathode and at the anode complex products, partly gaseous between —45 and —50°. The continued electrolysis leads to a strong polarisation of the electrodes (2·71 volts) and to a short-circuiting, by the dissolved sodium liberated ; the anode is thus depolarised, the current intensity rises, and the gas evolution ceases ; some of the gases are hydrocarbons of the acetylene and ethylene groups. H. B.

374. *Influence of the Magnetic Field on the E.M.F. of Galvanic Cells and upon Chemical Processes.* **W. Rathert.** (Zeitschr. Elektrochem. 20. pp. 145–151, 1914.)—The contradictory statements of various experimenters as to these influences can be explained on the assumption that concentration changes take place in the solutions as suggested by Bucherer. When the couple Fe | $FeSO_4$ | $CuSO_4$ | Cu is prepared with all care, so that only ferrous (no ferric) salt is present, and the couple is placed in a strong electromagnetic field, there is no change at all in the e.m.f. when the field is suddenly turned on or reversed. According to Remsen copper should not be deposited uniformly on iron when a sheet of iron is placed on a magnetic pole and $CuSO_4$ is poured on the iron ; there would be less copper deposited immediately above the pole than farther away from it. This is partly confirmed only. The deposition is quite uniform at first, but differences appear after some time, because the $FeSO_4$ formed is more magnetic than the $CuSO_4$ and is therefore attracted to the iron by the field, so that the $CuSO_4$ cannot readily diffuse through to the iron above the pole. The deposition remains quite uniform when the $CuSO_4$ is stirred. When the iron plate is replaced by zinc, the opposite effect is observed (*i.e.*, more copper is deposited near the pole), as it should be, because $ZnSO_4$ is paramagnetic to $CuSO_4$ (not diamagnetic as $FeSO_4$) ; similar or opposite effects are also obtained with Ag and with Fe and Zn in different salt solutions or acids. Owing to concentration changes an e.m.f. may be set up under the following conditions. The couple : Fe magnetised | H_2SO_4 | Fe non-magnetised, does not give a current and iron is dissolved at both electrodes ; when the first electrode is surrounded by a strong field, however, an e.m.f. is set up, because the concentration in $FeSO_4$ is now changed. The field is, however, not strong enough to separate previously prepared mixtures of salts into layers of more and of less magnetic solutions, nor can a varnished bar magnet, dipped into a mixture, affect a separation. When two iron rods, one magnetised the other not, are dipped into $CuSO_4$, however, it can easily be seen that the rates of diffusion from the two electrodes of the $FeSO_4$ formed are different. But there is no difference in the solubility of magnetised and of non-magnetised iron as suggested by Remsen and others. H. B.

375. *Connection between Electrolytic and Purely Chemical Processes.* III. **D. Reichinstein.** (Zeitschr. Elektrochem. 20. pp. 406–417, 1914.)—The phenomena of passivity are of the nature of purely chemical reactions

characterised by an abnormal rate/concentration curve, the anomaly being that with increasing concentration of one of the active components the velocity of the reaction first increases and then decreases. In chemical kinetics this means that at the boundary solid-liquid or solid-gas the sum of all the concentrations remains constant; this displacement-hypothesis accounts, *e.g.* for negative depolarisation, whilst any, ever so slow reaction, whose velocity regularly increases with the concentration in accordance with the laws of chemical kinetics, can never lead to any passivity. A great many special examples of the displacement-hypothesis are discussed, one of the oldest known being the luminescence of phosphorus in oxygen, which increases with increasing partial oxygen-pressure, but only to a certain maximum. The particular problems dealt with are: the conception of the degree of passivity; general equations for the purely-chemical dissolution of metals; and the "kinetic paradox" that the more passive metal may be dissolved at a greater velocity than the more active metal, with special regard to experiments (by the author and E. P. de Petherd) on the dissolution of nickel in solutions of ($H_2O_2 + H_2SO_4$). This dissolution takes place according to: (*a*) adsorption of H_2O_2; (*b*) $H_2O_2 \longrightarrow O + H_2O$; (*c*) $2O \longrightarrow O_2$; (*d*) $Ni + O + 2H^{\cdot} \longrightarrow Ni^{\cdot\cdot}$ and H_2O. Of these reactions, *b*, *c*, *d* are slow; (*c*) leads to a slow accumulation of ballast (O_2) in the electrode volume; with small acid percentages both (*b*) and (*c*) give rise to a slowly-progressing passivation. Between the concentrations 0·183-N and 0·366-N H_2O_2 the rate of the stationary (independent of time) dissolution of the Ni decreases strongly with the increasing concentration of the H_2O_2. H. B.

376. *Impurities of Aluminium Electrolytic Valves.* **G. Schulze.** (Zeitschr. Elektrochem. 20. pp. 307–310, 1914.)—The action of electrolytic valves of Al is much influenced by impurities in the electrolyte. The experiments were made by determining the formation curves in 0·22-N solution of borax; the Al electrode was a rod, 4 mm. in diam.; the other electrode was a foil of Pt. The most common and most injurious impurity is NaCl, of which 0·5 % is sufficient to disturb the action; the effect is really due to the Cl ions, and as the other halogens are likewise injurious, solutions of borax which become turbid when silver nitrate is added should not be used. Of $NaNO_3$ and $KMnO_4$ 1 % may be tolerated; NaOH is deleterious only when it is sufficiently concentrated to dissolve the Al. H. B.